# Appendix A

## US EPA Administrative Order Letter of Sept. 2010

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Region 1
1 Congress Street, Suite 1100
BOSTON, MA 02114-2023

SEP 30 2010

**CERTIFIED MAIL - RETURN RECEIPT REQUESTED**

Mr. Bernard F. Lynch, City Manager
City of Lowell
City Hall
375 Merrimack Street
Lowell, MA 01852

Re: In the Matter of City of Lowell, Lowell Regional Wastewater Utility
Administrative Order Docket No. 010-026

Dear Mr. Lynch:

Enclosed is an Administrative Order ("Order") issued by the U.S. Environmental Protection Agency ("EPA") pursuant to Section 309(a)(3) of the Clean Water Act (the "Act"), 33 U.S.C. § 1319(a)(3). The Order is based on violations of Section 301(a) of the Act, 33 U.S.C. § 1311(a), and of the limits and conditions contained in National Pollutant Discharge Elimination System ("NPDES") Permit No. MA0100633 (the "Permit"). Specifically, the Order finds that: 1) the City has exceeded the average annual flow limit contained in the Permit; 2) the City's combined sewer overflows ("CSOs") are causing or contributing to violations of water quality standards in the Merrimack and Concord Rivers and Beaver Brook in violation of the conditions of the Permit; and 3) overflows from the City's separate sewer system into streets and buildings have occurred in violation of the conditions of the Permit. The Order sets interim limits for average annual flow, requires the City to submit a proposal for a Phase 1A CSO abatement program and a scope of work for completion of a final CSO Long-Term Control ("LTCP") plan, and conduct a wastewater collection system Capacity, Management, Operation and Maintenance ("CMOM") assessment.

EPA recognizes that the City is nearing completion of a more than $76 million Phase 1 CSO abatement program. This work has reduced the volume and frequency of discharges from the City's CSOs, but considerable work remains to be done. The intent of this Order is to maintain the City's momentum toward reducing its CSO discharges while developing a final solution to the problem. EPA further recognizes that the violations of the average annual flow limit are due to the City's efforts to reduce its untreated CSO discharges by maximizing the amount of flow taken by the wastewater treatment facility. The interim flow limit reflects these efforts.

The Order is effective upon receipt. Violation of the terms and conditions of this Order may subject the City to further enforcement action under the Act.

If you have any questions regarding the requirements of the Order please contact George Harding, P.E., of the Water Enforcement Unit at 617/918-1870, or Attorney Michael Wagner at 617/918-1735.

Sincerely,

Susan Studlien

Susan Studlien, Director
Office of Environmental Stewardship

cc w/enc: Kevin Brander, DEP NERO
Mark Young, LRWU
John Donovan, CDM
James Drake, CDM

**UNITED STATES ENVIRONMENTAL PROTECTION AGENCY**
**REGION I**

| | |
|---|---|
| IN THE MATTER OF:<br><br>City of Lowell<br>Lowell Regional Wastewater Utility<br>First Street Boulevard (Route 110)<br>Lowell, Massachusetts 01850<br><br>NPDES Permit No.MA0100633<br><br>Proceedings under Sections 308 and 309(a)(3) of the Clean Water Act, as amended, 33 U.S.C. §§ 1318 and 1319(a)(3) | DOCKET NO. 010-026<br><br>FINDINGS OF VIOLATION<br><br>AND<br><br>ORDER FOR COMPLIANCE |

## I. STATUTORY AUTHORITY

The following Findings are made and ORDER issued pursuant to Sections 308(a) and 309(a)(3) of the Clean Water Act, as amended (the "Act"), 33 U.S.C. §§ 1318 and 1319(a)(3). Section 309(a)(3) of the Act grants to the Administrator of the U.S. Environmental Protection Agency ("EPA") the authority to issue orders requiring persons to comply with Sections 301, 302, 306, 307, 308, 318 and 405 of the Act and any permit condition or limitation implementing any of such sections in a National Pollutant Discharge Elimination System ("NPDES") permit issued under Section 402 of the Act, 33 U.S.C. § 1342. Section 308(a) of the Act, 33 U.S.C. § 1318(a), authorizes EPA to require the submission of any information required to carry out the objectives of the Act. These authorities have been delegated to EPA Region I's Regional Administrator, and in turn to the Director of EPA of the Office of Environmental Stewardship ("Director").

The Order herein is based on findings of violation of Section 301 of the Act, 33 U.S.C. § 1311, and the conditions of NPDES Permit No. MA0100633. Pursuant to Section 309(a)(5)(A) of the Act, 33 U.S.C. § 1319(a)(5)(A), the Order provides a schedule for compliance which the Director has determined to be reasonable.

## II. DEFINITIONS

Unless otherwise defined herein, terms used in this Order shall have the meaning given to those terms in the Act, 33 U.S.C. § 1251 *et. seq.*, the regulations promulgated thereunder, and any applicable NPDES permit. For the purposes of this Order, "NPDES Permit" means the Lowell Regional Water and Wastewater Utility's NPDES Permit, No. MA0100633, and all amendments or modifications thereto, and renewals thereof as are applicable, and in effect at the time.

## III. FINDINGS

The Director makes the following findings of fact:

1. The City of Lowell, Massachusetts ("City," "Lowell," or "Permittee") is a municipality, as defined in Section 502(4) of the Act, 33 U.S.C. § 1362(4), and therefore a person as defined in Section 502(5) of the Act, 33 U.S.C. § 1362(5).
2. The City is the owner and, through the Lowell Regional Wastewater Utility, a department of the City of Lowell, operator of a Publicly-Owned Treatment Works ("POTW") which includes a wastewater collection system ("Collection System"), a wastewater treatment facility ("WWTF") and nine combined sewer overflow ("CSO") outfalls from which it discharges pollutants, as defined in Section 502(6) and (12) of the Act, 33 U.S.C. §§ 1362(6) and (12), from point sources, as defined in Section 502(14) of the Act, 33 U.S.C. § 1362(14). The WWTF discharges into the Merrimack River via Outfall No. 035, and the CSO outfalls discharge flow into the Merrimack River, the Concord River, and Beaver Brook. The Concord River and Beaver Brook discharge into the Merrimack River, which discharges into the Atlantic Ocean. All are waters of the United States as defined in 40 CFR § 122.2 and navigable waters under 502(7) of the Act, 33 U.S.C. § 1362(7).
3. On September 1, 2005, the City was issued NPDES Permit No. MA0100633 ("NPDES Permit") by the Director of the Office of Ecosystem

Protection of EPA, Region I, under the authority of Section 402 of the Act, 33 U.S.C. § 1342. The NPDES Permit became effective on November 1, 2005, and expires on October 31, 2010.

4. Part I.A of the Permit authorizes the Permittee to discharge pollutants from the WWTF subject to the effluent limitations and monitoring requirements established therein. The effluent limitations include, inter alia, a moving-average annual average flow limit of 32 million gallons per day.

5. Part I.F of the Permit authorizes the Permittee to discharge from the specified CSO outfalls to the Merrimack and Concord Rivers and Beaver Brook provided that, inter alia, the Permittee maximizes flow to the WWTF for treatment and the discharges shall not cause or contribute to violations of Federal or State Water Quality Standards.

6. Part I.C of the Permit provides that discharges of wastewater from any other point sources, including sanitary sewer overflows, are not authorized.

7. As evidenced by discharge monitoring reports ("DMRs") submitted to EPA by the Permittee, the quantity of flow discharged from the WWTF consistently exceeds the NPDES Permit limit. These NPDES Permit exceedances are attributed to the high wet-weather flows received in the course of maximizing flow to the WWTF pursuant to Part I.F of the NPDES Permit.

8. The Permittee's discharge from the WWTF of flows in excess of the limit in Part I.A is not authorized by the NPDES Permit.

9. Discharges from the CSO outfalls contain high levels of fecal coliform bacteria. Fecal coliform bacteria is a pollutant within the meaning of Sections 502(6) and (12) of the Act, 33 U.S.C. §§ 1314(6) and (12). The Permittee has been implementing a Phase I CSO abatement program which has reduced but not eliminated these discharges from CSO outfalls. The remaining discharges from CSO outfalls cause or contribute to violations of State Water Quality Standards for fecal coliform bacteria in

the Merrimack and Concord Rivers and Beaver Brook in violation of the NPDES Permit.

10. The Permittee's discharge of coliform bacteria from its CSO outfalls in quantities that cause or contribute to violations of State Water Quality Standards is not authorized by the NPDES Permit.

11. During wet-weather conditions, untreated wastewater has overflowed (wet-weather sanitary sewer overflows) from various components of the Collection System other than permitted outfalls into building basements and onto streets. Some of these overflows are discharged from point sources into the Merrimack and Concord Rivers and Beaver Brook, either directly, through tributary streams, or the City's canal system.

12. Untreated wastewater contains pollutants within the meaning of Section 502(6) and (12) of the Act, 33 U.S.C. §§ 1314(6) and (12).

13. The Permittee's discharge of wastewater from wet-weather sanitary sewer overflows is not authorized by the NPDES Permit.

14. Section 301(a) of the Act, 33 U.S.C. § 1311(a), makes unlawful the discharge of pollutants to waters of the United States except, among other things, in compliance with the terms and conditions of an NPDES permit issued pursuant to Section 402 of the Act, 33 U.S.C. § 1342. The Permittee's discharge from the WWTF of flows in excess of the limit in Part I.A, the Permittee's discharge of coliform bacteria from its CSO outfalls in quantities that cause or contribute to violations of State water Quality Standards, and the Permittee's discharge of wastewater from wet-weather sanitary sewer overflows have occurred in violation of the Permit and Section 301(a) of the Act, 33 U.S.C. § 1311(a).

## IV. ORDER

Accordingly, pursuant to Sections 308 and 309(a)(3) of the Act, it is hereby ordered that:

**CSO Abatement Projects**

1. Within 90 days of receipt of this Order, the Permittee shall submit to EPA and the Massachusetts Department of Environmental Protection ("MassDEP") for review and approval a detailed plan for a Phase 1A CSO abatement program. The plan shall include a description of each element of the program, its estimated cost, a schedule for its completion, and its CSO benefits. The plan shall include a schedule for the completion of a Final Long-Term CSO Control Plan ("FLTCP") and Environmental Impact Report ("EIR"). The Phase 1A schedule shall require the completion of any element of the program involving optimization of in-line system storage prior to conducting any flow monitoring required to develop the FLTCP. Upon written approval of the plan by EPA and MassDEP, the approved plan and schedule shall become an enforceable requirement of this Order.
2. Within 150 days of the receipt of this Order, the Permittee shall submit to EPA and MassDEP for review and approval a High Flow Management Plan ("HFMP"). The HFMP shall include: 1) an evaluation of the maximum flow that can be provided full secondary treatment by the WWTF; 2) an evaluation of the maximum flow that can be provided at least primary treatment and disinfection by the WWTF; and 3) facility management procedures, including the WWTF, the collection system, and the CSO outfalls, to maximize the flow reaching the WWTF, maximize the level of pollutant removal provided by the WWTF, maximize the in-line storage within the collection system, and minimize the volume of discharges through CSO outfalls.
3. By June 30, 2011, the Permittee shall submit to EPA and MassDEP for review and approval a detailed Scope of Work ("SOW") for completion of a FLTCP and EIR. The SOW shall reflect the approved Phase 1A schedule, and shall conform to the EPA's *Combined Sewer Overflow Control Policy*, 1994.

**Interim Effluent Limits**

5. From the effective date of this Order until issuance of a new Permit or this Order is modified or superseded, the limitation for Annual Average Flow through the WWTF shall be monitor only. The Permittee shall continue to monitor and report on its WWTF flow in accordance with the requirements of Part I.A.1the NPDES Permit. The Permittee shall continue to maximize flow to the WWTF in accordance with the requirements of Part I.F of the NPDES Permit.

6. The Permittee shall also comply with all other effluent limitations, monitoring requirements and other conditions specified in its NPDES Permit for parameters that are not addressed in Paragraph IV.5. above.

**Capacity, Management, Operation and Maintenance ("CMOM") Program Assessment**

7. Within 180 calendar days of the effective date of this Order, the Permittee shall complete and submit:
   a. an inventory of the City's Collection System that characterizes the age, condition, type of construction, and operation of each element of its Collection System and provides for further assessments where warranted;
   b. an assessment of the capacity of critical elements of the Collection System; and
   c. an assessment of the City's operation and maintenance practices all of which shall comprise the "CMOM Program Self-Assessment".

As part of the assessments, the City shall determine whether improvements to the City's preventative maintenance practices are necessary in order to preserve the infrastructure of the Collection System and to prevent future overflows from the Collection System. The CMOM Program Self-Assessment shall be conducted in accordance with EPA's Guide for Evaluating Capacity, Management, Operation, and Maintenance (CMOM) Programs at Sanitary Sewer Collection Systems (EPA 305-B-05-

002, January 2005) ) (available on-line at http://www.epa.gov/npdes/pubs/cmom_guide_for_collection_systems.pdf). As part of the CMOM Program Self Assessment, the City shall complete and submit the Wastewater Collection System CMOM Program Self-Assessment Checklist (the "CMOM Program Self-Assessment Checklist") (see Attachment 1), which is a Region 1 modification of the checklist that accompanies the above CMOM guidance.

**CMOM Corrective Action Plan**

8. Within 365 calendar days of the effective date of this Order, submit a plan (the "CMOM Corrective Action Plan") that shall include the following:

   a. a list of any deficiencies identified by the CMOM Program Self-Assessment;

   b. a list of causes and contributing factors that lead to the overflows identified in response to this Order and the CMOM Program Self-Assessment Checklist;

   c. a description of the specific short and long-term actions that the City is taking, or plans to take, to address any of the deficiencies identified during the completion of the CMOM Program Self-Assessment Checklist; and

   d. a schedule for implementation of the CMOM Corrective Action Plan (the "CMOM Corrective Action Plan Implementation Schedule").

9. The CMOM Corrective Action Plan Implementation Schedule shall be incorporated and enforceable hereunder upon approval by, and as amended by, EPA and MassDEP.

**CMOM Program Document**

10. Within two years of the effective date of this Order, the Permittee shall consolidate all of the Collection System preventative and reactive maintenance programs and Collection System capital improvement plans into a single CMOM Program document. The CMOM Program document

shall be maintained at a location that is readily accessible to the City's maintenance staff, and is available for inspection by EPA and MassDEP.

11. Until further notice, beginning May 1, 2012, and each May 1st annually thereafter, the Permittee shall submit a report (the "CMOM Program Implementation Annual Report"), detailing the actions taken by the City during the prior calendar year, or known by the City to have been taken by other parties, to resolve the deficiencies identified in the CMOM Corrective Action Plan and to comply with this Order. The CMOM Program Implementation Annual Report shall also include:

    a. a summary listing of all unauthorized discharges, overflows, spills, and releases that have occurred during the previous calendar year, including building/private property backups, that result from capacity limitations, blockages, or mechanical, electrical or structural failures in that portion of the Collection System owned by the City. The tabular listing shall be organized chronologically and shall include:

        i. the dates and times on which each event began and was stopped, or if it is continuing, a schedule for its termination;

        ii. the location (nearest address) of each such event;

        iii. the source of the notification (property owner, field crew, police);

        iv. the cause of the event, including but not limited to, whether it was caused by debris, fats, oils, and grease, or root blockages, collapsed pipes, mechanical, electrical and structural failures, hydraulic overloads and/or vandalism;

        v. the estimated gallons of wastewater released, and the method used to estimate the volume;

        vi. a description of the ultimate fate of the overflow including whether it occurred in a building, on private property, onto the ground, to the street, and whether it discharged to a surface water including the name of the surface water. If the release occurred to the ground or street, provide the location of the nearest down-gradient stormwater catch basin and the name of the receiving water for that portion of the stormwater collection system;

vii. the estimated gallons of wastewater discharged to the stormwater collection system or surface water and the method used to estimate the volume;

viii. the measures taken to stop the overflow and prevent future overflows at the same location;

ix. the date that overflow was reported to the EPA and MassDEP; and

x. the date of the last overflow that occurred at the same location.

The location of each event included in the summary listing shall also be noted on a map of the City's Collection System.

b. a description of the measures and programs implemented by the City to resolve any of the deficiencies identified pursuant to Paragraphs IV.7. and IV.8. of this Order and to reduce the frequency, duration and volume of unauthorized discharges, overflows, spills, and releases from the City's Collection System during the previous calendar year including copies of any contracts signed by the City to address any issues identified in the CMOM Corrective Action Plan. The report shall also include a description of the activities that the City has implemented to measure the effect and success of its efforts;

c. a description of the type of the City's Collection System mapping (i.e. GIS, paper) and the last date the map(s) was updated;

d. copies of the annual Collection System operation and maintenance budgets for the current and previous fiscal year noting the source of the funding – enterprise fund, general tax rate. Specifically indicate whether a capital replacement fund ("sinking fund") has been established to provide for replacement of aging wastewater Collection System infrastructure. Provide the Collection System maintenance staffing levels for the current fiscal year including:

i. budgeted positions;

ii. vacant positions; and

iii. a brief description of the responsibilities of each position clearly distinguishing Collection System maintenance responsibilities from responsibilities for the WWTF and other public works operations.

e. a description of any existing or proposed City programs designed to reduce the levels of extraneous flows that enter the City's Collection System and the specific measures that were taken by the City under these programs during the past calendar year including whether properties are inspected during the property transfer process to determine whether infiltration/inflow sources are tied into the Collection System;

f. a description of any existing or proposed City easement maintenance programs for locating and uncovering lost or buried Collection System manholes and the specific measures that were taken by the City under these programs during the past calendar year; and

g. a projection of the measures that will be taken during the current calendar year to resolve any deficiencies identified in the CMOM Corrective Action Plan and to comply with this Order.

**Third Year CMOM Program Self-Assessment Checklist**

12. Three years from the effective date of this Order, the Permittee shall submit an updated CMOM Program Self-Assessment Checklist in addition to the annual report required pursuant to Paragraph 11. of this Order.

**Semi-Annual Progress Reports and Work Projections**

13. Beginning with the period ending on September 30, 2011, and continuing until otherwise directed in writing by EPA, the Permittee shall submit semi-annual reports on the City's progress in implementing the provisions of this Order. The reports shall be submitted by the last day of the month following the semi-annual monitoring period. At a minimum, these progress reports shall include a description of:
    a. Activities undertaken during the reporting period directed at achieving compliance with this Order;
    b. A summary of the status of all plans, reports, and other deliverables required by this Order that the City completed and submitted during the reporting period; and
    c. Expected activities completed during the next reporting period in order to achieve compliance with this Order.

## V. NOTIFICATION PROCEDURE

1. Where this Order requires a specific action to be performed within a certain time frame, the Permittee shall submit a written notice of compliance or noncompliance with each deadline. Notification must be mailed within fourteen (14) days after each required deadline. The timely submission of a required report shall satisfy the requirement that a notice of compliance be submitted.
2. If noncompliance is reported, notification should include the following information:
    a. A description of the noncompliance;
    b. A description of any actions taken or proposed by the Permittee to comply with the lapsed schedule requirements;
    c. A description of any factors that explain or mitigate the noncompliance; and

d. An approximate date by which the Permittee will perform the required action. After a notification of noncompliance has been filed, compliance with the past-due requirement shall be reported by submitting any required documents or providing EPA with a written report indicating that the required action has been achieved.

3. Submissions required by this Order shall be in writing and shall be mailed to the following addresses:

U.S. Environmental Protection Agency, Region I
5 Post Office Square, Suite 100 (OES04-4)
Boston, MA 02109-3219
Attn: George W. Harding, P.E.

and

Massachusetts Department of Environmental Protection
Municipal Services Section
DEP Northeast Regional Office
205B Lowell Street
Wilmington, MA 01887
Attention: Kevin Brander, P.E.

## VI. GENERAL PROVISIONS

1. The Permittee may, if it desires, assert a business confidentiality claim covering part or all of the information requested, in the manner described by 40 C.F.R. § 203(b). Information covered by such a claim will be disclosed by EPA only to the extent set forth in 40 C.F.R. Part 2, Subpart B. If no such claim accompanies the information when it is received by EPA, the information may be made available to the public by EPA without further notice to the Permittee. The Permittee should carefully read the above-cited regulations before asserting a business confidentiality claim since certain categories of information are not properly the subject of such a claim. For example, the Act provides that "effluent data" shall in all cases be made available to the public. See Section 308(b) of the Act, 33 U.S.C. § 1318(b).

2. This Order does not constitute a waiver or a modification of the terms and conditions of the NPDES Permit. The NPDES Permit remains in full force and effect. EPA reserves the right to seek any and all remedies available under Section 309 of the Act, 33 U.S.C. § 1319, as amended, for any violation cited in this Order.

3. This Order shall become effective upon receipt by the Permittee.

09/30/10
Date

Susan Studlien
Susan Studlien, Director
Office of Environmental Stewardship
Environmental Protection Agency, Region I

Attachment No. 1

United States Environmental Protection Agency, EPA New England

**Wastewater Collection System CMOM Program Self-Assessment Checklist – September 2009**

**Name of your system** ______________________________ **Date** __________

**Put an "A" in the final column for an issue you intend to address with future action, or leave blank if you have evaluated your program as sufficient.**

## I. General Information – Collection System Description

| I | Question | Response | *Act |
|---|---|---|---|
| 1 | Identify the number of people currently served by your wastewater collection system. | | |
| 2 | Identify the number of service connections to your collection system. Specify the number of residential, commercial, and industrial connections. Provide a list of the commercial and industrial connections. Provide the number of manholes, pump stations, force mains, and siphons. Provide the length (in feet or miles) of gravity sewers and force mains? List by size and type. | | |
| 3 | What is the age of your system (e.g., percentage over 100, 75, 50, 30, etc. years old)? | | |
| 4 | Type(s) and age of collection system maps that are available and what percent of the system is mapped by each method (e.g., paper only, paper scanned into electronic, digitized, interactive GIS, etc.)? | | |
| 5 | Indicate whether you have a systematic numbering and identification method/system to identify sewer system manholes, sewer lines, and other components (pump stations, etc.). Please describe. | | |
| 6 | Are "as-built" plans (record drawings) or maps available and used by field crews in the office and in the field? | | |
| 7 | Describe the type of asset management (AM) system you use (e.g. card catalog, spreadsheets, AM software program, etc.) | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

## II. Continuing Sewer Assessment Plan

| II | Question | Response | *Act |
|---|---|---|---|
| 1 | Describe under what conditions, if any, the collection system overflows. Does it overflow during both wet and dry weather? Characterize common causes of overflows: □ hydraulic capacity, □ debris, □ roots, □ Fats, Oils & Grease (FOG), □ vandalism, □ other (specify). Describe your system's history of structural collapses, and PS or force main failures. | | |
| 2 | Provide the number of sanitary sewer overflows (SSOs), including building and private property backups, that have occurred in each of the last three calendar years. In an attachment, provide the date, location, cause, volume and fate of the discharge for each SSO event. | | |
| 3 | Describe how you responded to the building and private property backups listed in II.2, including how you document the response, result of the investigation into the cause, and the ultimate fate of the discharge. | | |
| 4 | What is the ratio of peak wet-weather flow to average dry-weather flow at the wastewater treatment plant or municipal boundary for satellite collection systems? | | |
| 5 | Describe short-term measures that have been implemented or planned to mitigate overflows at each location. If actions are planned, when will they be implemented for each location? | | |
| 6 | Describe long-term measures that have been implemented or planned to mitigate overflows at each location. If actions are planned, when will they be implemented for each location? | | |
| 7 | Describe preventive maintenance programs; how are they tracked (e.g., card files, electronic spreadsheets, specific software)? Do you have a system to prioritize investigations, repairs and rehabilitation? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

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| 8 | Are chronic problem areas systematically identified and tracked? Is there an established schedule for more frequent maintenance for problem areas? How are these maintenance regimes tracked and evaluated? Is there an established program to identify and address underlying causes for problem areas? | | |
| 9 | If septage is accepted, are haulers required to declare the origin of their load? Are records of these declarations maintained? Are these declarations used to identify potential SSOs? | | |

**III.A. Collection System Management Organizational Structure**

| III A | Question | Response | *Act |
|---|---|---|---|
| 1 | Provide an organizational chart that shows the overall personnel structure for collection system operations, including operation and maintenance staff. | | |
| 2 | Provide up-to-date job descriptions that delineate responsibilities and authority for each position. | | |
| 3 | How many staff members work on collection system maintenance? If these workers are also responsible for other duties, (e.g., road repair or maintenance, O&M of the storm water collection system), what percentage of their time is dedicated to the collection system? | | |
| 4 | Are there any collection system maintenance position vacancies? How long have these positions been vacant? | | |
| 5 | For which, if any, maintenance activities do you use an outside contractor? | | |
| 6 | Describe any group purchase contracts you participate in. | | |

**III.B. Collection System Management: Training**

| III B | Question | Response | *Act |
|---|---|---|---|
| 1 | What types of training are provided to staff? | | |
| 2 | Is training provided in any of the following areas: □ general | | |

*Put an "A" in the final column if this is an issue you intend to address with future action.

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| | safety, □ routine line maintenance, □ confined space entry, □ MSDS □ lockout/tagout, □ biologic hazards, □ traffic control, □ record keeping, □ electrical and instrumentation, □ pipe repair, □ public relations, SSO/emergency response, □ pump station operations and maintenance, □ trenching and shoring, □ other (explain)? | | |
| 3 | Which training requirements, if any, are mandatory for key employees? | | |
| 4 | How many collection system employees are certified (e.g, NEWEA certification program) and at what grade are they certified? | | |

**III.C. Collection System Management: Communication and Customer Service**

| III C | Question | Response | *Act |
|---|---|---|---|
| 1 | Describe your public education/outreach programs (e.g., for user rates, FOG, extraneous flow, SSOs etc.)? | | |
| 2 | What are the most common collection system complaints? How many complaints have you received in each of the past three calendar years? | | |
| 3 | Are formal procedures in place to evaluate and respond to complaints? | | |
| 4 | How are complaint records maintained (e.g, logs, spreadsheets)? How are complaints tied to emergency response and operations and maintenance programs? | | |

**III.D. Collection System Management: Management Information Systems**

| III D | Question | Response | *Act |
|---|---|---|---|
| 1 | How do you manage collection system information? (Commercial software package, spreadsheets, data bases, SCADA, etc). What information and functions are managed electronically? | | |
| 2 | What procedures are used to track and plan collection system maintenance activities? | | |
| 3 | Who is responsible for establishing maintenance priorities? What records are | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| | maintained for each piece of mechanical equipment within the collection system? | | |
| 4 | What is the backlog for various types of work orders? | | |
| 5 | How do you track emergencies and your response to emergencies? How do you link emergency responses to your maintenance activities? | | |
| 6 | What written policies and protocols do you have for managing and tracking the following: scheduled and unscheduled work orders, including complaint response? Scheduled inspections and preventative maintenance? Safety incidents and emergency responses? Compliance and overflow tracking? Equipment and tools tracking? Spare parts inventory? | | |

**III.E. Collection System Management: SSO Notification Program**

| III E | Question | Response | *Act |
|---|---|---|---|
| 1 | What are your procedures, including time frames, for notifying state agencies, health agencies, regulatory authorities, and the drinking water authorities of overflow events? | | |
| 2 | Do you use a standard form to record and report overflow events? Provide a copy of the form that is used. | | |

**III.F. Collection System Management: Legal Authority**

| III F | Question | Response | *Act |
|---|---|---|---|
| 1 | Are discharges to the sewer regulated by a sewer use ordinance (SUO)? Does the SUO contain procedures for controlling and enforcing the following: □ FOG; □ defects in service laterals located on private property; □ building structures over the sewer lines; □ storm water connections to sanitary lines; □ sump pumps, roof drains and other private sources of inflow; □ Infiltration and Inflow (I/I);? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| 2 | Who is responsible for enforcing various aspects of the SUO? Does this party communicate with your department on a regular basis? | | |
| 3 | Summarize any SUO enforcement actions/activities that have occurred in the last three calendar years. | | |
| 4 | Is there a program to control FOG entering the collection system? If so, does it include the following elements: □ permits, □ minimum performance criteria, □ inspection □ enforcement? Are commercial grease traps inspected regularly? Who is responsible for inspections and enforcement? | | |
| 5 | Is there an ordinance dealing with storm water connections or requirements to remove storm water connections? | | |
| 6 | Does the collection system receive flow from satellite communities? If yes, which communities? How are flows from these satellite communities recorded and regulated? Are satellite flow capacity issues periodically reviewed? | | |
| 7 | Does the collection system receive flow from other collection systems (e.g. colleges and universities, military bases, or private collection systems)? If so, list these sources. How are flows from these collection systems recorded and regulated? Are there required inspection and maintenance programs? How are overflows addressed? How are overflows recorded and reported? | | |

**IV.A. Collection System Operation: Financing**

| IVA | Question | Response | *Act |
|---|---|---|---|
| 1 | Has an enterprise (or other) fund been established? Does it include: wastewater collection and treatment operations; collection system maintenance; long-term infrastructure improvements; | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| | etc.? Are the funds sufficient to properly fund future system needs? | | |
| 2 | How are rates calculated (have you done a rate analysis)? What is the current sewer charge rate? When was the last increase? How much was the increase? | | |
| 3 | What is your O&M budget? | | |
| 4 | If an enterprise fund has not been established, how are collection system maintenance operations funded? | | |
| 5 | Is there a Capital Improvement Plan (CIP) that provides for system repair/replacement on a prioritized basis exist? What is the collection system's average annual CIP budget? | | |
| 6 | How do you account for the value of your system infrastructure for the Government Accounting Standards Board Standard 34 (GASB 34)? | | |

### IV.B. Collection System Operation: Hydrogen Sulfide Monitoring and Control

| IV B | Question | Response | *Act |
|---|---|---|---|
| 1 | Are odors a frequent source of complaints? How many have been received in the last calendar year? List location(s) of complaints. | | |
| 2 | Do you have a hydrogen sulfide problem, and if so, do you have corrosion control programs? What are the major elements of the program? | | |
| 3 | Does your system contain air relief valves at the high points of the force main system? If so, how often are they inspected? How often are they exercised? | | |

### IV.C. Collection System Operation: Safety

| IV C | Question | Response | *Act |
|---|---|---|---|
| 1 | Do you have a formal Safety Training Program? If so, how do you maintain safety training records? | | |
| 2 | Are the following items are available and in adequate supply: □ rubber/disposable gloves; □ confined space | | |

*Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| | ventilation equipment; □ hard hats, □ safety glasses, □ rubber boots; □ antibacterial soap and first aid kit; □ tripods or non-entry rescue equipment; □ fire extinguishers; □ equipment to enter manholes; □ portable crane/hoist; □ atmospheric testing equipment and gas detectors; □ oxygen sensors; □ H2S monitors; □ full body harnesses; □ protective clothing; □ traffic/public access control equipment; □ 5-minute escape breathing devices; □ life preservers for lagoons; □ safety buoys at activated sludge plants; □ fiberglass or wooden ladders for electrical work; □ respirators and/or self-contained breathing apparatus; □ methane gas or OVA analyzer; □ LEL metering? | | |

### IV.D. Collection System Operation: Emergency Preparedness and Response

| IV D | Question | Response | *Act |
|---|---|---|---|
| 1 | Do you have a written collection system emergency response plan? If so, when was the plan last updated? What departments are included in your emergency planning? | | |
| 2 | Does the emergency response plan consider the following: □ vulnerable points in the system, □ severe natural events, □ a failure of critical system components, □ vandalism or other third party events (specify), □ other types of incidents (specify)? | | |
| 3 | How do you train staff to respond to emergency situations? Where are responsibilities detailed for personnel who respond to emergencies? | | |
| 4 | How many emergency calls have you had in the past calendar year? What was their nature? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

### IV.E. Collection System Operation: Engineering – Capacity

| IV E | Question | Response | *Act |
|---|---|---|---|
| 1 | How do you evaluate the capacity of your system and what capacity issues have you identified, if any? What is your plan to remedy the identified capacity issues? | | |
| 2 | What procedures do you use to determine whether the capacity of existing gravity sewer system, pump stations and force mains are adequate for new connections? Who does this evaluation? | | |
| 3 | Do you charge hook up fees for new development and if so, how are they calculated? | | |
| 4 | Do you have a hydraulic model of your collection system? Is it used to predict the effects of system remediation and new connections? | | |

### IV.F. Collection System Operation: Pump Stations - Inspection

| IV F | Question | Response | *Act |
|---|---|---|---|
| 1 | How many pump stations are in the system? How often are pump stations inspected? How many are privately owned, and how are they inspected? Do you use an inspection checklist? | | |
| 2 | Describe backup equipment at pump stations. Is there sufficient redundancy of equipment at all pump stations? | | |
| 3 | How are pump stations monitored? If a SCADA system is used, what parameters are monitored? | | |
| 4 | How many pump station/force main failures have you had in each of the last three years? Who responds to pump station/force main failures and overflows? How are the responders notified? | | |
| 5 | How many pump stations have backup power? How many require portable generators? How many portable generators does your system own? Explain how portable generators will be deployed during a system-wide electrical outage. | | |

*Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| 6 | Are operation logs maintained for all pump stations? Are the lead, lag, and backup pumps rotated regularly? | | |
| 7 | Are pump station operations adjusted (manually or automatically) during wet weather to maximize in-line storage of wet weather flows? | | |

### V.A. Equipment and Collection System Maintenance: Sewer Cleaning

| V A | Question | Response | *Act |
|---|---|---|---|
| 1 | Do you have a schedule for cleaning sewer lines on a system-wide basis? At this rate, how long does it take to clean the entire system? How is sewer line cleaning recorded? | | |
| 2 | How do you identify sewer lines that have chronic problems and should be cleaned more frequently? Is a list of these areas maintained and cleaning frequencies established? | | |
| 3 | Approximately, how many collection system blockages have occurred during the last calendar year, and what were the causes? How many resulted in overflows? | | |
| 4 | Has the number of blockages increased, decreased, or stayed the same over the past five years? | | |
| 5 | What equipment is available to clean sewers? Is sewer line cleaning ever contracted to other parties? If so, under what circumstances? | | |
| 6 | Do you have a root control program? Describe its critical components. | | |

### V.B. Equipment and Collection System Maintenance: Maintenance Right-of-Way

| VB | Question | Response | *Act |
|---|---|---|---|
| 1 | Is scheduled maintenance performed on Rights-of-Way and Easements? How often? How many manholes are located in easement areas? Are there problems locating and accessing these manholes. How many cannot be accessed or located? Are the manholes equipped with watertight and/or locking manhole covers? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| 2 | Are road paving operations coordinated with collection system operators. Are there manholes that have been paved over? If so, how many manholes have been paved over? Describe systems in place to locate and raise manholes that have been paved over. | | |

### V.C. Equipment and Collection System Maintenance: Parts Inventory

| V C | Question | Response | *Act |
|---|---|---|---|
| 1 | Do you have a central location for the storage of spare parts? | | |
| 2 | How have critical spare parts been identified? | | |
| 3 | How do you determine if adequate supplies are on hand? Has an inventory tracking system been implemented? | | |

### VI A. SSES: System Assessment

| VI A | Question | Response | *Act |
|---|---|---|---|
| 1 | Do flow records, or prior I/I or Sewer System Evaluation Survey (SSES) programs indicate public or private sources of inflow? Please explain. | | |
| 2 | If I/I studies or an SSES has been conducted? When were the studies conducted? What is the status of the recommendations? If no SSES or I/I have been conducted, is there a plan and schedule for conducting one? | | |
| 3 | Do you have a program to identify and eliminate sources of I/I into the system including private service laterals and illegal connections? If so, describe. | | |
| 4 | Have private residences and businesses been inspected for sump pumps and roof leader connections? If so, how many have been inspected what percentages of the total residences and businesses does this represent? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | | | |
|---|---|---|---|
| 5 | Are inspections to identify illicit connections conducted during the property transfer process? | | |
| 6 | How many sump pumps and roof leaders have been identified? How many have been removed? | | |
| 7 | Have follow-up residential and business inspections been conducted? | | |
| 8 | Are there incentive programs to encourage residences and businesses to disconnect roof leaders & sump pumps (e.g. matching funds)? | | |
| 9 | What disincentive programs exist to encourage residences and businesses to disconnect roof leaders & sump pumps (e.g. fines, surcharges)? | | |

**VI.B. SSES: Manhole Inspection**

| VI B | Question | Response | *Act |
|---|---|---|---|
| 1 | Do you have a manhole inspection and assessment program? If so, describe. | | |
| 2 | Is a formal manhole inspection checklist used? If so, provide a copy. | | |
| 3 | How many manholes were inspected during the past calendar year? What percentage of the total number of manholes in system? | | |

**VII. Energy Use**

| VII | Question | Response | *Act |
|---|---|---|---|
| 1 | What is your annual energy cost for operating your system? For which pieces of equipment do you track energy use? | | |
| 2 | Have you upgraded any of your pumps and motors to more energy efficient models? If so, please describe. | | |
| 3 | Have you performed an energy audit in the past three years? | | |
| 4 | Where do you use the most energy (fuel, electricity) in operating your collection system? | | |

* Put an "A" in the final column if this is an issue you intend to address with future action.

| | |
|---|---|
| 5 | If you have a treatment plant, would you be interested in participating i EnergyStar benchmarking of your treatment plant? |

**VIII. Other Actions**

| VIII | Question |
|---|---|
| 1 | Describe any other action: that you plan to take to improve your CMOM Program that are not discussed above. |

*Put an "A" in the final column if th

# Appendix B

## Model Calibration and Validation

(Refer to Section 4)

CDM Smith

# Memorandum

*To:* *FILE*

*From:* *Giana Park, Gary Mercer, and Mitch Heineman*

*Date:* *January 21, 2014*

*Subject:* *Lowell LTCP Update – Model Calibration and Validation*

As part of the Lowell LTCP Update, CDM Smith updated the LRWWU's sewer system model to represent existing system conditions and recalibrated its sanitary flow, hydrology, and hydraulic components to metering data collected at 24 sites in Lowell between April and September 2012. The model development and updates are described in the LTCP report. This memorandum summarizes the model calibration, model validation, and flow and rainfall monitoring data used for calibration.

## Flow Metering Data

A flow monitoring program was completed for the LRWWU to provide data for calibration of the collection system model. Temporary meters were installed by ADS Environmental Services from April 19, 2012 to September 23, 2012 at the 24 sites described in Table 1 and shown in Figure 1. Flow, depth, and velocity data at 15-minute intervals was provided for each site.

The Lowell Regional WWTF flow data was provided by LRWWU at 15-minute intervals for the calibration period and at daily intervals for 2010 through 2012. The LRWWU also provided 15-minute data for the calibration period from their SCADA system for available flow, depth, and gate operations at the CSO stations for model validation.

## Rainfall Data Analysis

LRWWU maintains a rainfall gauge at the Warren CSO station that records at 15-minute intervals. Figure 2 shows cumulative rainfall at the Warren CSO station, Hanscom Field (Bedford, MA), Lawrence, MA, and Hudson, NH for the calibration period. The Warren gauge tracks closely with the other gauges and was used for calibration.

A temporary rainfall gauge was installed at the Walker CSO station during the flow metering period; however, the cumulative rainfall total at this temporary gauge was approximately 5 inches less than the totals of the other gauges for the metering period. Therefore, this rain gauge was not used for calibration.

**Table 1 Temporary Metering Locations**

| Meter Site | Location | Pipe Size (Depth) |
|---|---|---|
| G1 | Off Pawtucket Street upstream of Walker Station | 48" |
| G2 | 520 Pawtucket Street upstream of Walker Station | 48" |
| G3 | Second Avenue at White Street | 63" |
| G4 | Beaver Brook Pump Station (Beaver Street and Martin Street) | 96" |
| G5 | West Street and Lakeview Avenue upstream of West Station | 96" |
| G6 | 427 Lakeview Avenue upstream of West Station | 54" |
| G7 | Riverside Avenue and West Street upstream of West Station | 68" |
| G8 | VFW Parkway (RT 110) upstream of West Station | 48" |
| G9 | North bank interceptor between West and Read Stations | 96" |
| G10 | Dog Park at 1st State Boulevard | 60" |
| G11 | North bank interceptor between Read Station and WWTP | 96" |
| G12 | 735 Branch Street | 41" |
| G13 | 34 Hurd Street upstream of Warren Station | 52.5" |
| G14 | Off Lowell Connector | 72" |
| G15 | Lawrence Street at Utility Pole 50 | 36" |
| G16 | 5 Watson Street | 90" |
| G17 | 132 Warren Street upstream of Warren Station | 90" |
| G18 | Arcand Drive at Tsongas Way upstream of Tilden Station | 72" |
| G19 | Tsongas Arena upstream of Tilden Station | 36" |
| G20 | 50 Stackpole Street downstream of Warren Station | 96" |
| G21 | Easement off Stackpole Street | 120" |
| G22 | East Merrimack at Barasford Street | 60" |
| G23 | 218 Douglas Road | 48" |
| G24 | 208 River Road on Merrimack East interceptor | 84" |

The daily rainfall totals at the Warren gauge for the calibration period are shown in Figure 3. The wet weather events during the calibration period with total depth of 0.2 inches or greater are summarized in Table 2. The largest storm during the calibration period occurred on April 22 with a total depth of 2.62 inches and a 1-year 33-hour average recurrence interval (ARI). The remaining storms had less amounts, with ARIs ranging from less than two weeks to three months.

**Figure 2 Cumulative Rainfall for Calibration Period**

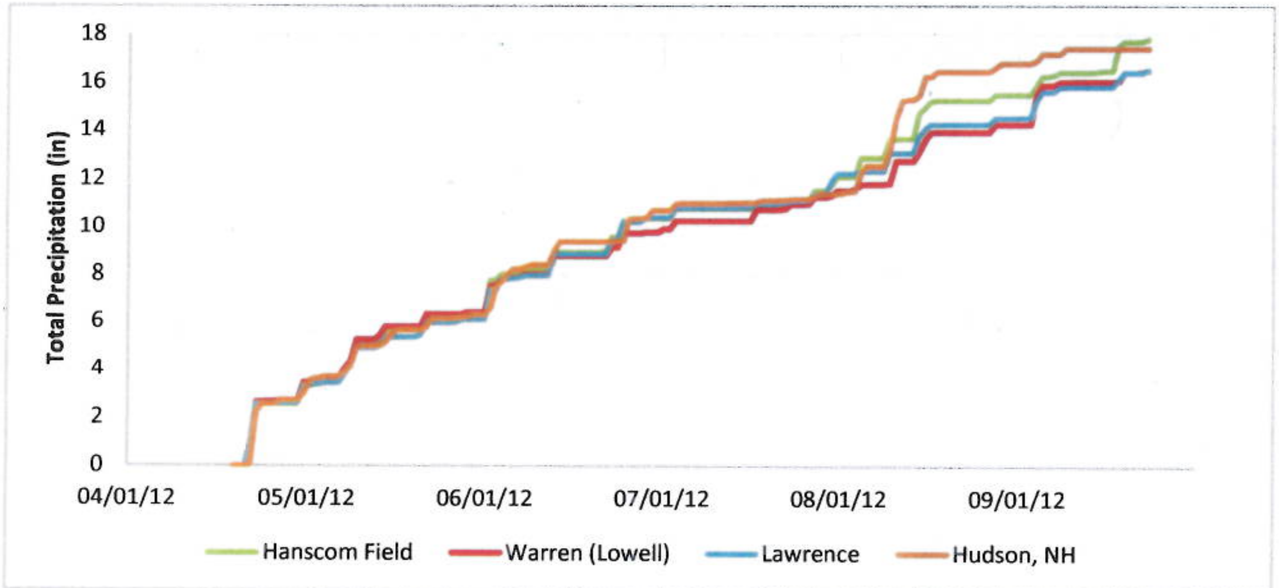



**Figure 3 Daily Rainfall at Warren Gauge**

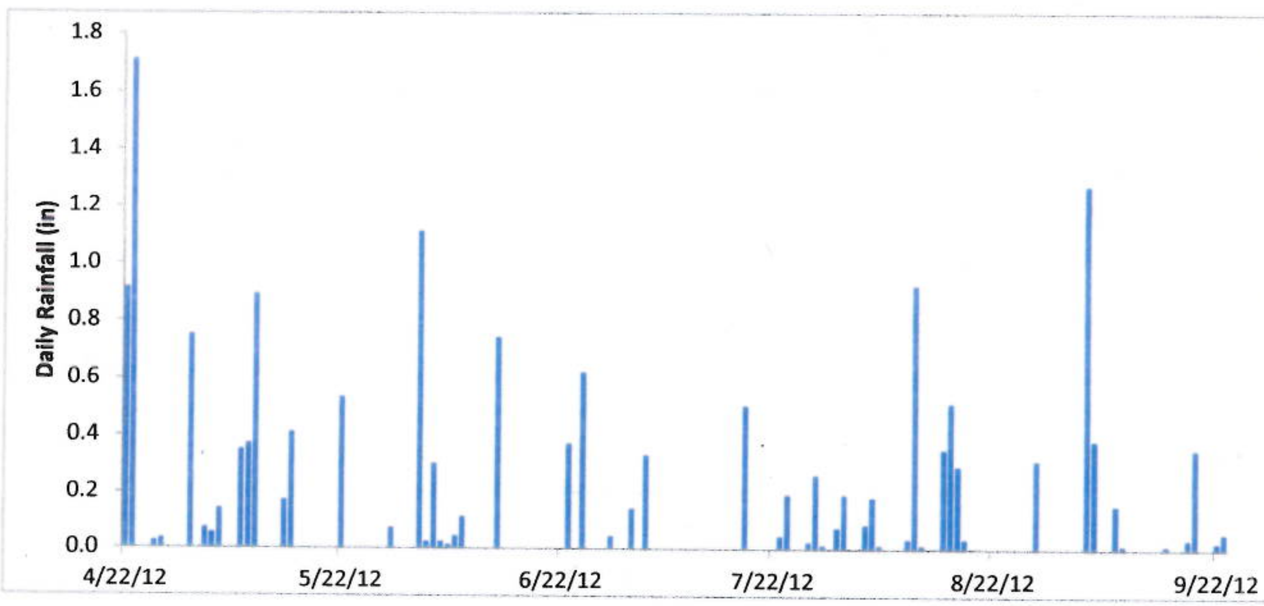


**Table 2 Wet Weather Events**

| Date | Depth (in) | Duration (hr) | Peak Hour Intensity (in/hr) | Recurrence Interval[1] |
|---|---|---|---|---|
| 04/22/2012 08:45 | 2.62 | 33 | 0.34 | 1-year |
| 09/04/2012 06:00 | 1.65 | 26 | 0.97 | 3-month |
| 05/09/2012 18:45 | 1.24 | 20 | 0.20 | 2-month |
| 06/02/2012 06:30 | 1.12 | 19 | 0.29 | 1-month |
| 08/11/2012 08:15 | 0.92 | 10 | 0.76 | 1-month |
| 05/01/2012 04:45 | 0.74 | 10 | 0.16 | 1-month |
| 06/13/2012 00:30 | 0.74 | 13 | 0.11 | 1-month |
| 06/25/2012 10:15 | 0.62 | 4 | 0.30 | 1-month |
| 08/15/2012 23:30 | 0.57 | 9 | 0.24 | 1-month |
| 05/22/2012 04:00 | 0.53 | 17 | 0.13 | 2-week |
| 07/18/2012 13:30 | 0.50 | 1 | 0.50 | 3-month |
| 05/15/2012 13:45 | 0.40 | 10 | 0.19 | 2-week |
| 09/18/2012 18:15 | 0.38 | 9 | 0.30 | 2-week |
| 05/08/2012 05:30 | 0.35 | 18 | 0.07 | 2-week |
| 06/23/2012 16:15 | 0.35 | 2 | 0.33 | 2-week |
| 07/04/2012 04:45 | 0.33 | 4 | 0.16 | 2-week |
| 08/17/2012 21:45 | 0.32 | 3 | 0.27 | 2-week |
| 06/04/2012 01:45 | 0.31 | 25 | 0.06 | < 2-week |
| 08/28/2012 06:15 | 0.31 | 4 | 0.24 | 2-week |
| 08/15/2012 07:45 | 0.29 | 2 | 0.24 | 2-week |
| 07/28/2012 16:45 | 0.26 | 6 | 0.07 | 2-week |

[1]Based on total depth and total duration of event

## Dry Weather Flow Estimates

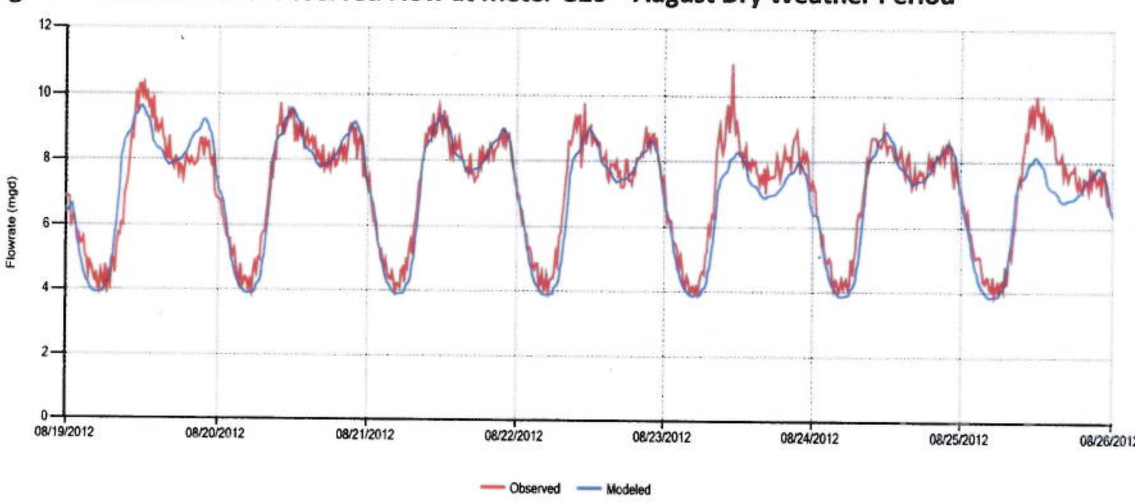
Dry weather flow includes diurnally varied sanitary flow along with infiltration from groundwater. Groundwater levels and pipe infiltration were directly simulated using SWMM's groundwater simulation component. Initial groundwater and aquifer parameters were based on typical values used in other urban collection system models in New England and then were adjusted to match long-term seasonal groundwater trends observed in the WWTF flow data. Average sanitary flow during dry weather was estimated at each temporary meter location from conditions observed over a seven-day dry period from August 19-25, 2012. Estimated flow contributions from Tyngsboro, Tewksbury, Dracut, and Chelmsford were subtracted from temporary meter flows to allocate flows within Lowell and for each outside community. Hourly and daily patterns were developed from the metering and WWTF flow data and applied to the average sanitary flows.

## Dry Weather Calibration

The model was initially calibrated to a dry weather period from August 19-25, 2012. Initial dry weather flow estimates were adjusted to match measured discharge data at the meter locations. Manning's coefficients for conduits was initially set to 0.013 and adjusted between 0.011 and 0.025 to calibrate depth and velocity. High calibrated Manning's may be due to combined effects of pipe age, unknown obstructions, and sediment accumulation. Sediment was added to some conduits to improve depth calibration, based on comments from LRWWU and where sediment accumulation seemed likely based on metering data and pipe configuration. Form loss coefficients were applied at some conduits to account for head loss due to pipe bends or other obstructions, such as a root ball observed downstream of the Tilden CSO station.

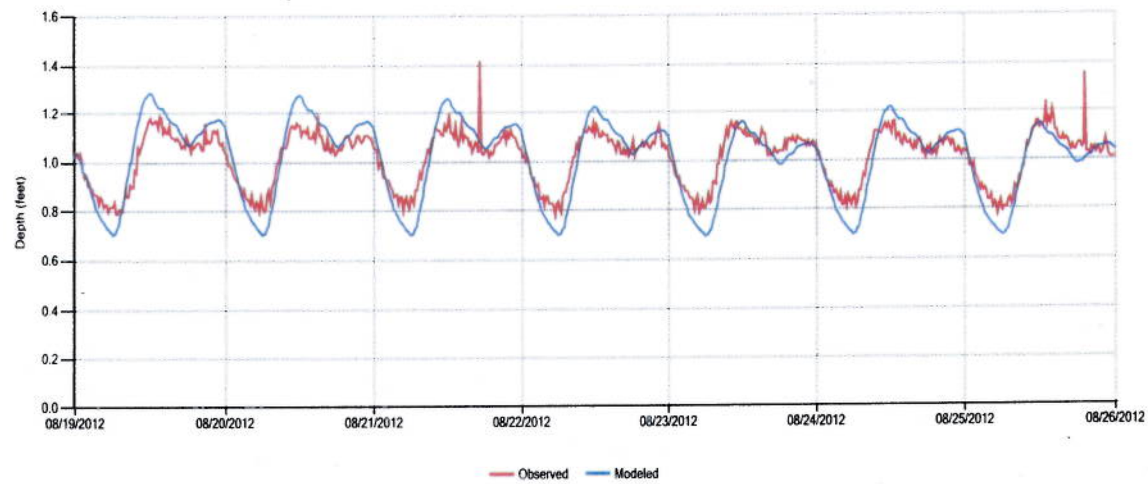
Figure 4 shows a time series of simulated and observed flow at meter G20 during the August dry weather period. Meter G20 was located on the 96" Merrimack West interceptor downstream of the Warren CSO station. The dry weather calibration plots for flow, velocity, and depth for all of the temporary meters are presented in Attachment 1. At some locations, the model underestimated or overestimated depth and velocity; however, these sites had low flow through a large pipe or low velocities, which may be difficult to accurately measure. The simulated flows closely follow the observed data at the metering sites, except at meters G9 and G11 where a flow imbalance in the observed data was identified. Meter G9 was upstream of meter G11, and both meters were located on the north bank interceptor upstream of the WWTF. The flow imbalance is also shown on the hydrograph for the WWTF effluent, where the simulated flow appears higher than the observed flow. During wet weather calibration; however, a flow imbalance at these meters was not apparent.

**Figure 4 Simulated and Observed Flow at Meter G20 – August Dry Weather Period**




Time series plots of simulated and observed depths at the CSO stations during the August dry weather period are also provided in Attachment 1. The model shows a reasonable match with the observed data at most stations. The largest difference between simulated and observed depths was at the influent channel and siphon channel at Warren station; however, the depth calibration is within acceptable limits (WaPUG criteria) during wet weather, which is more critical for CSO analysis. The simulated and observed depth in the influent channel at the Beaver Brook CSO station is shown in Figure 5.

**Figure 5 Simulated and Observed Influent Channel Depth at Beaver Brook CSO Station – August Dry Weather Period**




Following calibration to the August dry weather period, model results were also compared to data from a dry weather period from May 17-21, 2012. The calibration plots for the May dry weather period for the temporary meters and CSO stations are included in Attachment 2. The locations where the model underestimated or overestimated depth and velocity were generally the same for the August and May dry weather periods. However, the August flow imbalance in the observed data at meters G9 and G11 was not apparent during the May dry weather period. Overall, a good dry weather calibration was achieved.

## Wet Weather Calibration

The model accounts for various wet weather flow contributions to the sewer system, including drainage from combined areas; infiltration and inflow (I/I) from separated areas in Lowell and from sewered areas in Chelmsford, Dracut, Tewksbury, and Tyngsboro; and drainage from Dracut including Humphrey's Brook, Hovey Field, and the Billings Street wetland.

Three principal storms occurring on April 22, May 9, and June 2, 2012 were selected for primary wet weather calibration. Statistics for these events are provided in Table 2.

LRWWU provided 2012 SCADA data for all its CSO stations, except First Street, which is not operated. The SCADA output included time series of gate operations (percent open), channel and interceptor depths, and station flows. The station flows were mostly based on Parshall flume sensors, which were generally considered less accurate than the depth sensors. Therefore, the Parshall flume flow data was used mostly for comparison to simulated flows but not for calibration. For the calibration period, the SCADA data time series for the gate operations were used directly in the model to ensure that the correct gate settings were being applied. Control logic for the gates was later applied for design storm and long-term simulations to assess system performance under existing and alternative conditions. The control logic is based on the 2013 High Flow Management Plan (HFMP) and operation and maintenance (O&M) manuals for the CSO stations.

Subcatchment contributing impervious area and width were adjusted to calibrate runoff into the system. Manning's and loss coefficients were further modified as necessary to improve depth and velocity calibration. Discharge coefficients for gates at the CSO station gates were also adjusted to match channel depths indicated by SCADA. The root ball downstream of the Tilden CSO station was represented with loss coefficients and 1.5 feet of sediment in a 36-inch pipe. The root ball was removed after the 2012 metering period and was assumed to be in place for the duration of the calibration period, as suggested by LRWWU.

Figure 6 shows the simulated and observed flow, velocity, and depth at meter G9 for the June 2 storm. Meter G9 was located on the 96" interceptor between the West and Read CSO stations. The simulated and observed flow at the Duck Island WWTF for the June 2 storm is shown in Figure 7. The calibration hydrographs for all of the temporary meters for each of the calibration storms are provided in Attachment 3.

As discussed in section 2.2.5 of this report, the LRWWU uses local PLCs and a SCADA system for real-time control of the collection system, including monitoring flow depths and remote and automatic operation of most of the CSO stations. From the Duck Island WWTF, the LRWWU can remotely actuate flow control gates and pumps in each CSO station, except at the First Street, Read Street, and Walker Street stations. This remote gate actuator system allows the LRWWU to utilize inline storage in the interceptor upstream of each station, control flow to the downstream interceptor, and control CSO discharges. A summary of the operations at each station is below.

- **Walker CSO Station** –Wet weather flows in excess of the siphon capacity overtop a weir into a wet well, where discharge pumps are activated automatically based on the wet well level. There is no gravity diversion at this structure. The flow control gate at the siphon influent is not automated, and its position remains constant. The flow control gate was set to 80% open for the model simulations, based on 2012 operating data.

**Figure 6 Simulated and Observed Flow, Velocity, and Depth at Meter G9 – June 2, 2012 Storm**

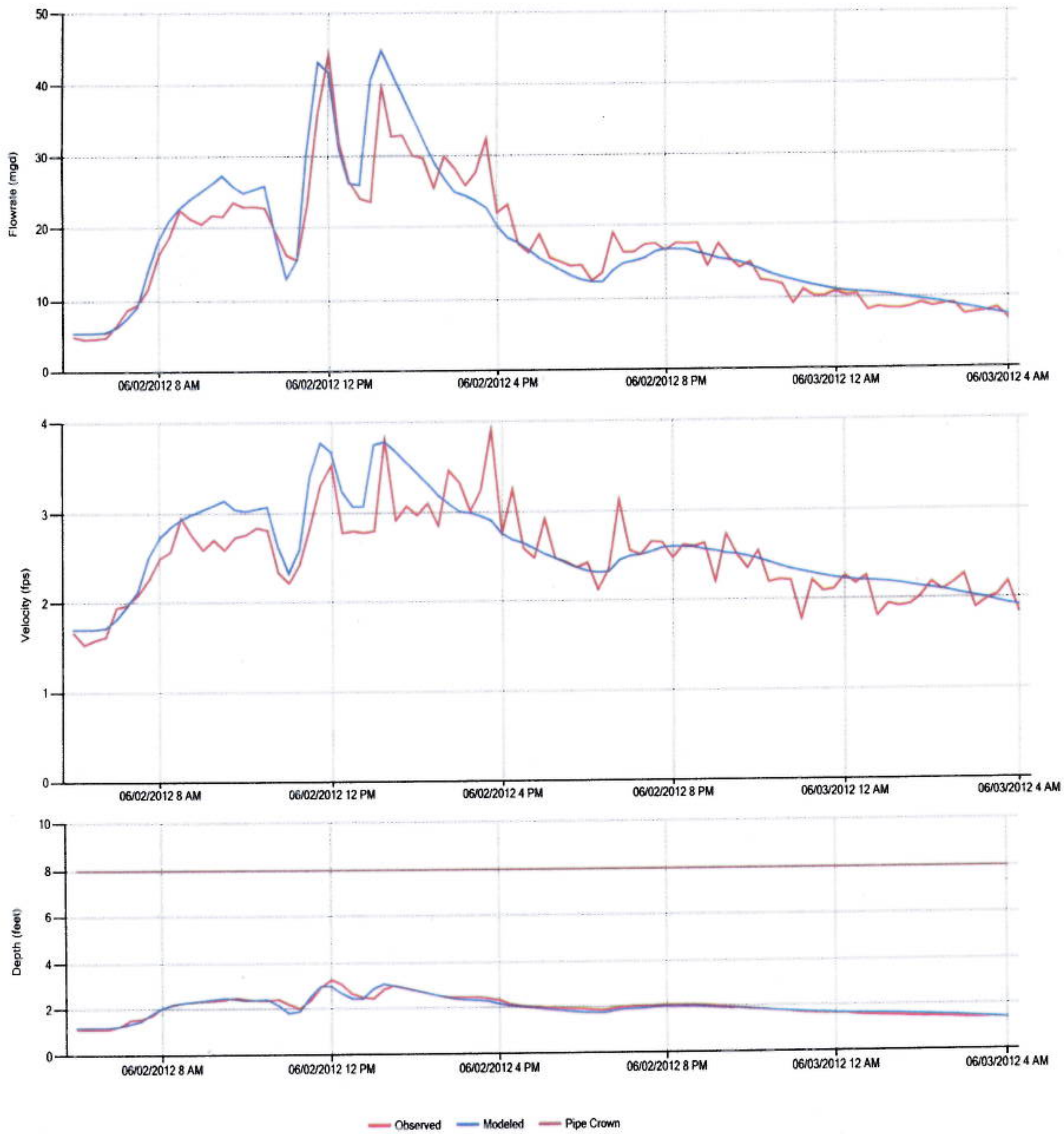
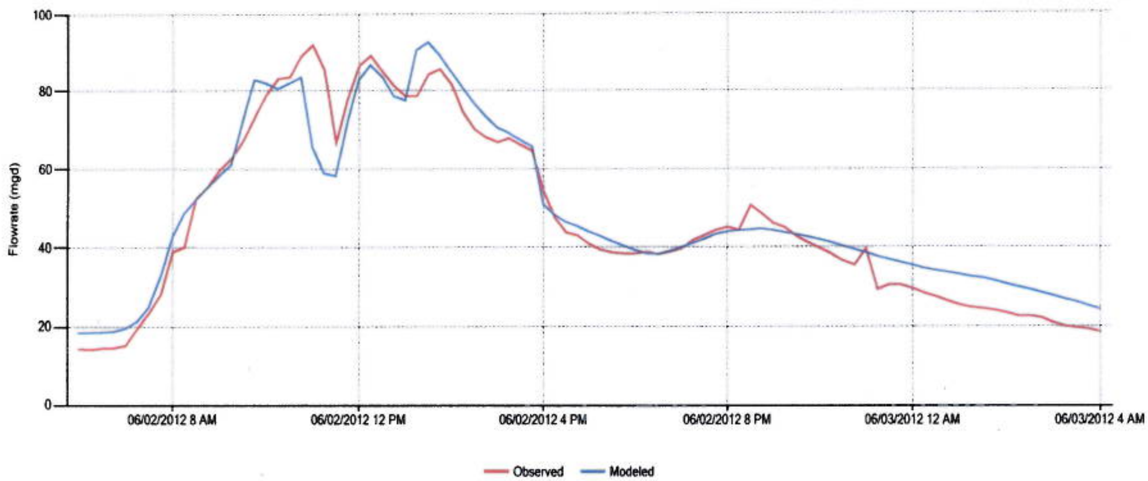


**Figure 7 Simulated and Observed Flow at Duck Island WWTF – June 2, 2012 Storm**




- **Beaver Brook CSO Station** – The LWRRU uses the bar rack gates to control flow through the influent channel and utilize inline storage in the upstream interceptor. The gates are programmed to first maintain a maximum level in the influent channel below the CSO discharge point and then maintain a maximum level in the interceptor for inline storage. When inline interceptor storage is maximized and the siphon or flow control gate setting capacity is exceeded, CSO discharge occurs first over the weir to the gravity diversion chamber and then over a higher weir to the wet well where flow is automatically pumped to Beaver Brook. The flow control gate is operated automatically based on the siphon channel level to control flow to the downstream interceptors and the WWTF.
- **West CSO Station** – The LWRRU operates the flow control gate to store flow upstream of the station and limit flow conveyed downstream to the WWTF. The flow control gate is automatically operated by logic controls based on the WWTF influent and depth in the West and Merrimack interceptors, or manually controlled by WWTF operators. Manual over-rides typically occur to assist in control of flow to the WWTF. The diversion gate is operated through the SCADA system and is programmed to open at and maintain a high influent channel level to utilize storage in the upstream interceptor.
- **Read CSO Station** – CSO diversions occur when the influent channel level rises above a weir in the outlet chamber. The LRWWU does not remotely operate any gates at this structure. The flow control gate remains fully open.
- **First CSO Station** – Wet weather flow can be manually diverted to the outfall by opening the discharge gate. Since flow through the First Street CSO station is small, the LRWWU does not operate or monitor this station.

- **Tilden CSO Station** – The gravity and pumped diversion gates, flow control gate, and diversion pumps are operated via the SCADA system. The flow control gate is controlled based on the depth measured at the Parshall flume near the station effluent. The diversion gates are operated based on the influent channel depth and are set to utilize inline storage in the upstream interceptor. The diversion gate to the wet well opens at a higher level than the gravity diversion gate, and both gates are modulated to maintain the same depth in the influent channel.

- **Warren CSO Station** – The flow control gate and gravity diversion gates are automatically controlled through the SCADA system. The flow control gate is normally fully open and is operated based on the depth in the siphon channel to limit flow to the bar screen. The CSO diversion gates are programmed based on the influent channel level and are set to utilize inline storage in the upstream interceptor.

- **Barasford CSO Station** – The LRWWU automatically operates the flow control gate and gravity diversion gate with the SCADA system. The flow control gate operates based on the Merrimack interceptor depth, and the diversion gate opens and closes based on the influent channel depth. The diversion gate will often open as soon as the flow control gate starts to close.

- **Merrimack CSO Station** - The LRWWU uses the flow control gate to control flow to the WWTF from the south bank interceptors. Similar to the flow control gate at the West CSO station, this gate is remotely controlled through the SCADA system based on WWTF flow and depth in the West and Merrimack interceptors, or manually operated to limit flow to the WWTF. The diversion gates are programmed to open based on the influent channel depth and are set to utilize inline storage in the upstream interceptors. As the influent channel level rises, flow can enter the wet well through openings along the influent channel wall. The diversion pumps are automatically activated based on the wet well level.

The overall operation of the collection system and activation of the CSO stations during wet weather involves a complex series of automatic logic controls in the SCADA system and manual over-rides by WWTF operators based on characteristics of incoming storms, time of day, and WWTF operations. The control logic for operation at the Beaver Brook, West, Tilden, Warren, and Merrimack CSO stations are primarily based on local conditions at each station, with the intent to utilize inline storage in the upstream interceptors. The LRWWU operates the flow control gates at the West and Merrimack CSO stations to balance and control flow to the WWTF from the north and south bank interceptors. The control logic is aimed at maximizing flow to the WWTF while maximizing inline storage in the West and Merrimack interceptors.

The simulated and observed influent channel depth at the West CSO station during the June 2 storm is shown in Figure 8. The CSO discharge gate at the West station is set to open when the influent channel depth reaches 10 feet. The gate will modulate to maintain a depth of 10 feet in the influent channel. Hydrographs for simulated and observed depths at the CSO stations for each of the calibration storms are also included in Attachment 3. The influent channel depths at which the CSO discharge gates are set to open at each station, as programmed in the SCADA system and specified in the model, are summarized in Table 3. The depths at which overflow occurs at stations without controlled discharge gates are also included in Table 3.

**Figure 8 Simulated and Observed Influent Channel Depth at West CSO Station – June 2, 2012 Storm**

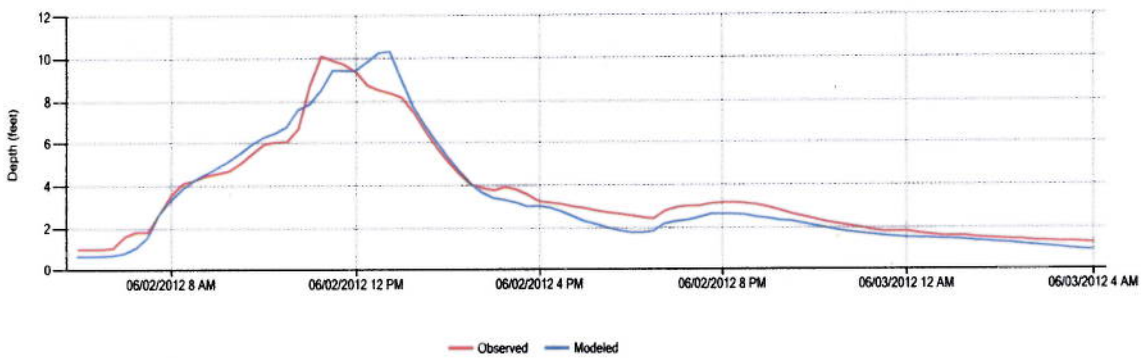



**Table 3 Overflow Depths[1] at CSO Stations**

| CSO Station | Gravity Discharge Gate | Wet Well Gate |
|---|---|---|
| **Operational Depths (ft) for CSO Discharge Gates** | | |
| West Street | 10.0 | - |
| Tilden Street | 5.0 | 5.5 |
| Warren Street | 6.5 | - |
| Merrimack River | 9.2 | 7.0[2] |
| Barasford Avenue | 4.5 | - |
| **Overflow Weir Depths (ft)** | | |
| Walker Street | - | 4.5 |
| Beaver Brook | 4.8 | 6.0 |
| Read Street | 9.8 | - |

[1]Depth in the influent channel

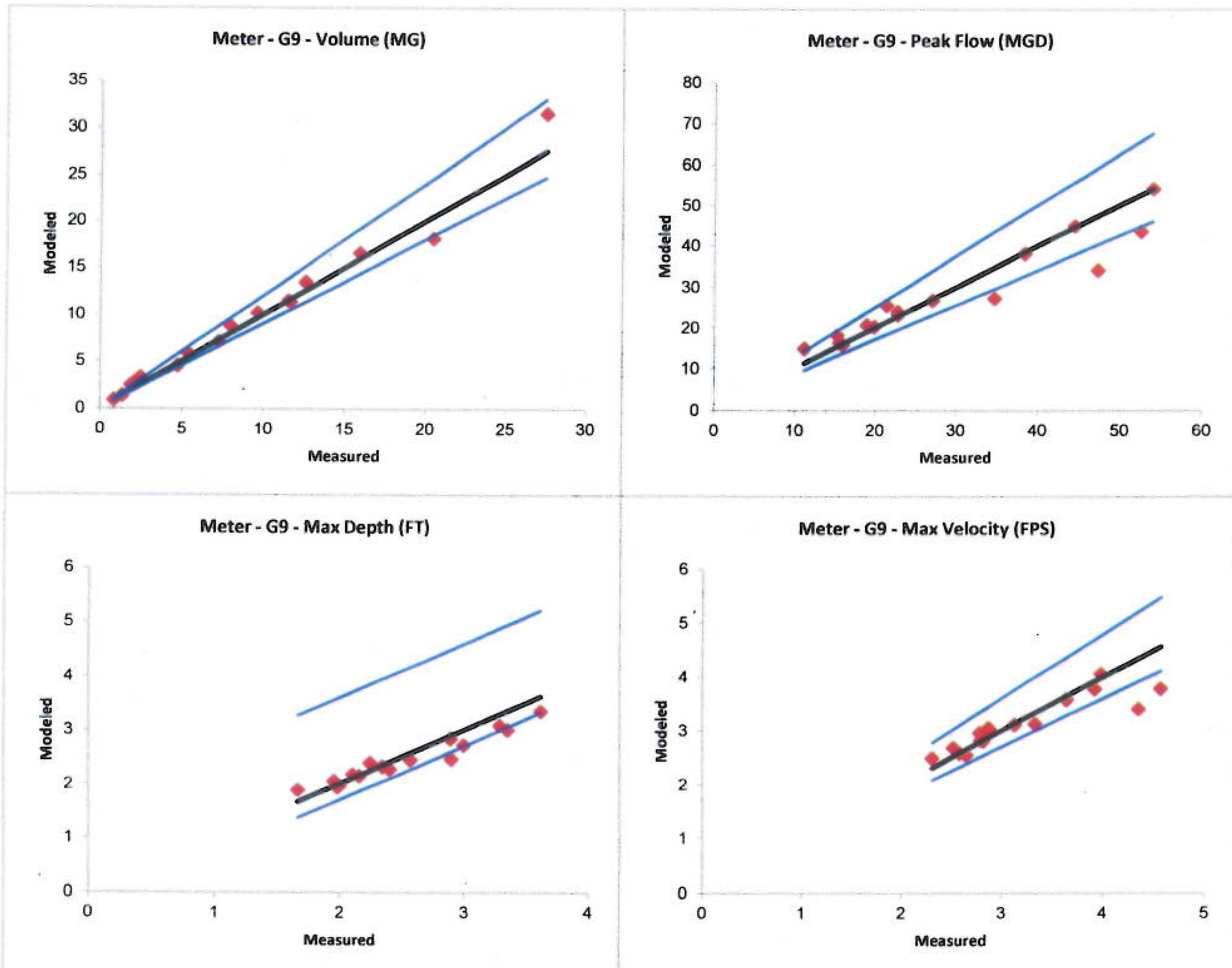
[2]Overflow to the wet well at the Merrimack CSO station is controlled by a weir (no gate).

Scatter plots were generated to assess the overall wet weather calibration for the entire metering period for the temporary meters and depth sensors at the CSO stations. Figure 9 includes scatter plots showing the relationship between simulated versus observed events for peak flow, depth, velocity, and total volume at meter G9, which was located on the 96" interceptor between the West and Read CSO stations. The black 45° line indicates the one-to-one correspondence between simulated and observed events. Events that are overestimated by the model lie above the 45° line;

events that are underestimated lie below. Calibration was assessed according to WaPUG criteria, which are shown on the plots with the boundary lines. WaPUG criteria are summarized as:

- Peak flow rates should be in the range of +25% to -15%;
- Volume of flow should be in the range of +20% to -10%; and
- Depth of flow should be in the range of +0.5 m to -0.1 m.

**Figure 9 Scatter Plots for Peak Flow, Depth, Velocity, and Total Volume at Meter G9**




Points, or storm events, that fall between the blue lines on the scatter plots meet the WaPUG criteria, indicating acceptable calibration. Model results were also assessed to limit any bias towards consistent high or low estimation. Scatter plots comparing simulated and observed peak flows, depths, velocities, and total volume for all meters for 18 events during the metering period are included in Attachment 4. The July 18, August 11, and September 4 events were omitted from the scatter plots. The July 18 event was a short, intense thunderstorm, and the August 11 and September 4 events were also high intensity storms with spatial variability. When compared to other gauges surrounding Lowell, the rainfall totals at the Warren gauge for these events were higher and may not be representative of rainfall for all of Lowell.

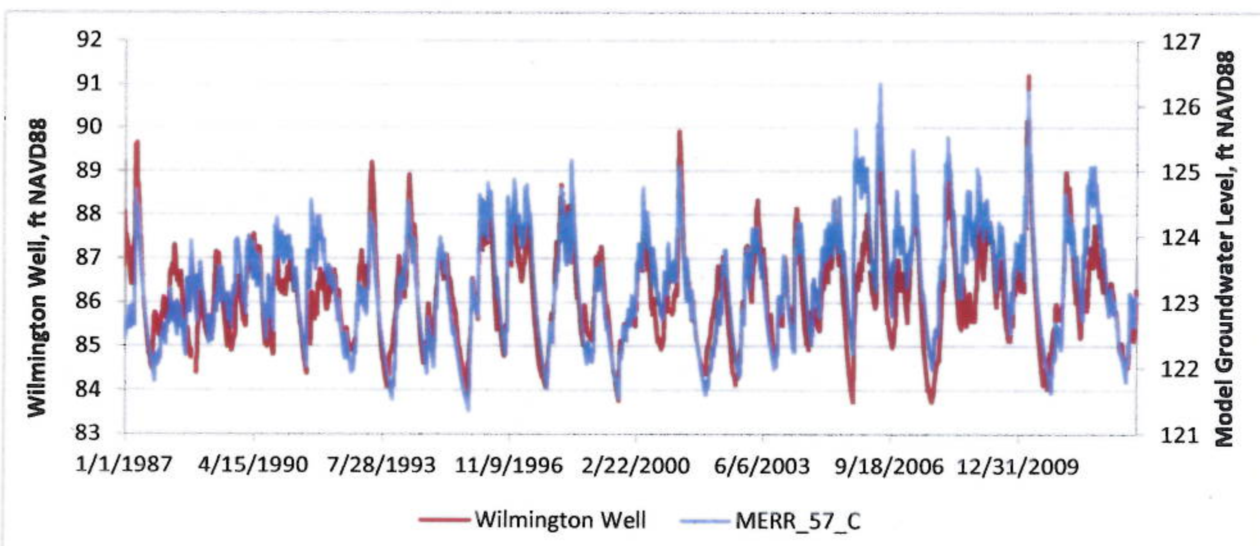
## Model Validation

### *Groundwater Infiltration*

Following wet weather calibration, the model was run from 1987 through 2012 to ensure that seasonal variation of infiltration was adequately simulated. Daily precipitation data from the Hudson, NH gauge (274234) was synthetically disaggregated to hourly intervals for use in the long-term simulation. The disaggregation method used in NetSTORM is based on a method developed by Socolofsky (2001) for use in watershed modeling where local hourly data are not available. As groundwater levels fluctuate on a time scale of days, actual hourly rainfall variation is not important to water table level simulation.

Simulated groundwater levels were compared to observed water table elevations at the USGS well in Wilmington, MA (MA-XMW 78, 10 miles southeast of Lowell). Figure 10 compares the observed groundwater levels with model results at a catchment tributary to the Merrimack CSO station. Similar plots for other catchment areas are included in Attachment 5. The model reasonably mimics seasonal groundwater trends observed over the 26-year simulation period.

**Figure 10 Simulated and Observed Groundwater Levels for 1987-2012**




A continuous simulation from 2010 through 2012 was also performed to assess the simulated infiltration into the collection system. The simulated and observed flows at the WWTF were compared and show similar trends in the seasonal variation of the groundwater infiltration.

***2012 Validation Simulation***

The model was run for 2012 to compare simulated annual overflow with reported values. Control logic was applied in the model for gate operations at the CSO stations based on the April 2013 HFMP protocol and O&M manuals for each station. Representation of the root ball downstream of the Tilden CSO station was included in the model for the full simulation, although the actual duration that the root ball was in place is unknown. The root ball was not discovered until after the 2012 flow monitoring period.

Reported and simulated annual CSO statistics for 2012 are shown in Table 4. Detailed daily summaries of CSO volume and duration are provided in Attachment 6. Overall, the model results match reasonably well with the reported values. The differences between the simulated and reported CSO are most likely due the following:

- Control logic for simulated gate operations – Control logic was specified in the model for operation of flow control (effluent) and CSO discharge gates based on the HFMP protocol (April 2013) and the O&M manuals for each station, as programmed in the SCADA system. The control logic includes specific set points (i.e., influent channel or interceptor depths) that must be reached before gates open or close. If these exact depths are not simulated, the gates will not operate in the model, even if the simulated depth is just below or above the set points.
- Manual operation of gates – The LRWWU noted that operation of gates at the West and Merrimack CSO stations was often switched from automatic to manual mode during 2012. The manual over-rides were based on operator judgment and assessment of system conditions, and therefore, could not be simulated by the model.

***Annual Average WWTF Flow***

The annual average WWTF flow based on continuous simulation of a five-year representative period (2005-2009) is summarized in Table 5. The selection of the five-year representative period is discussed in Appendix C. Simulations using the selected five-year period are performed to estimate average annual CSO statistics under existing system conditions and various alternatives.

As shown in Table 5, the simulated annual average flow at the WWTF ranged from 29 to 33 MGD, with an overall average of 30 MGD. These results are similar to the existing reported average flow rate at the WWTF, which is approximately 28 MGD.

**Table 4 Annual 2012 CSO Statistics**

| | | Reported | | | Simulated | | |
|---|---|---|---|---|---|---|---|
| | | Number of Events | Volume (MG) | Duration (hours) | Number of Events | Volume (MG) | Duration (hours) |
| **North Bank** | | | | | | | |
| Beaver Brook | 007 | 8 | 3.0 | 8.4 | 5 | 3.3 | 5.5 |
| First Street | 012 | 0 | 0 | 0 | 0 | 0 | 0 |
| Read Street | 011 | 0 | 0 | 0 | 2 | 1.9 | 1.3 |
| Walker Street | 002 | 2 | 2.5 | 0.7 | 2 | 1.3 | 1.3 |
| West Street | 008 | 13 | 36.2 | 27.9 | 7 | 12.4 | 15.8 |
| **South Bank** | | | | | | | |
| Barasford | 030(1) | 10 | 8.3 | 31.0 | 1 | 0.7 | 0.3 |
| Merrimack | 030(2) | 14 | 42.2 | 37.2 | 9 | 28.1 | 31.0 |
| Tilden Street | 027 | 18 | 12.4 | 30.1 | 11 | 14.7 | 23.8 |
| Warren Street | 020 | 15 | 20.5 | 23.6 | 11 | 33.8 | 17.3 |
| **Total** | | | **125.1** | | | **96.1** | |

**Table 5 Simulated Annual Average WWTF Flow**

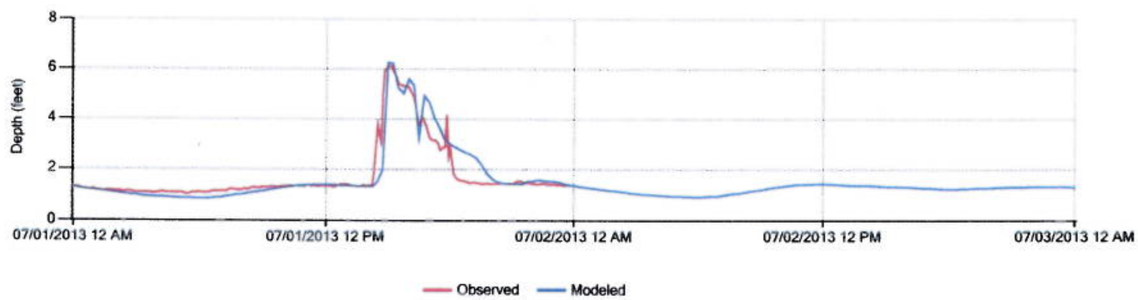
| | WWTF Average Flow (MGD) | Precipitation (inches) |
|---|---|---|
| 2005 | 29 | 41 |
| 2006 | 33 | 52 |
| 2007 | 29 | 35[1] |
| 2008 | 29 | 53 |
| 2009 | 31 | 42 |
| Overall Average | 30 | 45 |

[1]Total excludes high intensity storms on July 27 and 30, 2007.

***July 2013 Storm***

The largest storm during the 2012 calibration period was a 1-year event on April 22. The model was also run for a recent storm that occurred on July 1, 2013, using data provided by LRWWU from the rain gauge at the Duck Island WWTF. This storm had a total depth of 1.6 inches and peak 15-minute depth of 0.6 inches with a 2-year 3-hour ARI. Simulated and observed depths at the CSO stations and flow at the WWTF were similar in most places (Attachment 7). Figure 11 compares the simulated and observed depths in the influent channel at the Beaver Brook station for the July 1 event.

**Figure 11 Simulated and Observed Influent Channel Depth at Beaver Brook CSO Station – July 1, 2013 Storm**



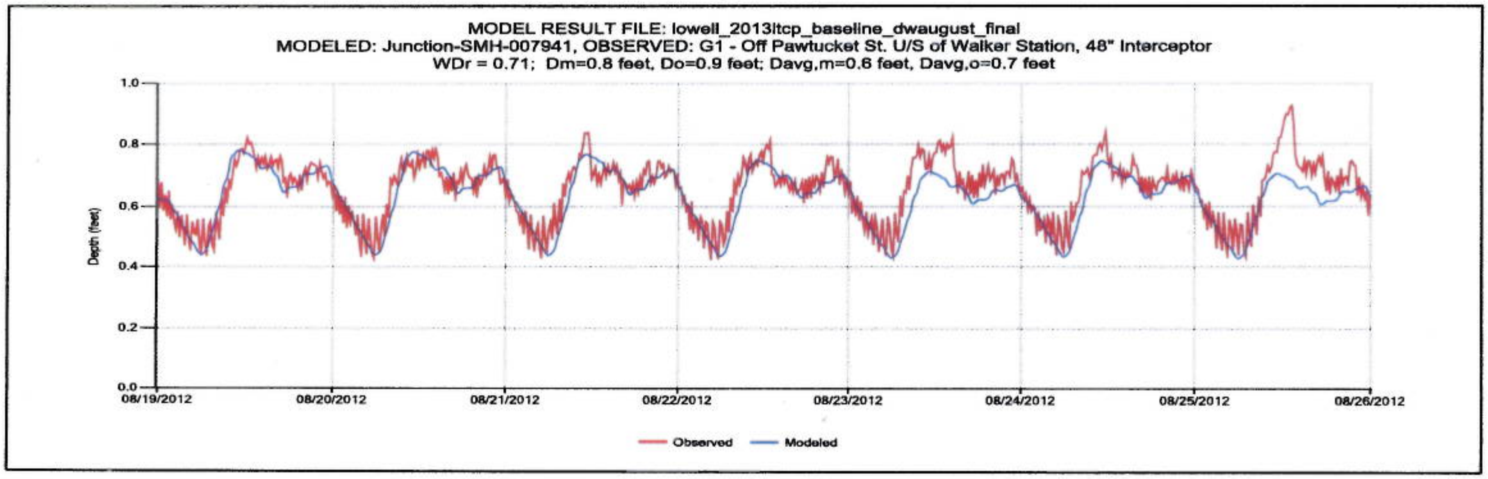

Based on the overall calibration and validation simulations performed, the model is a valuable tool for assessing the existing state of the system and analyzing the impacts of planned and potential improvements.

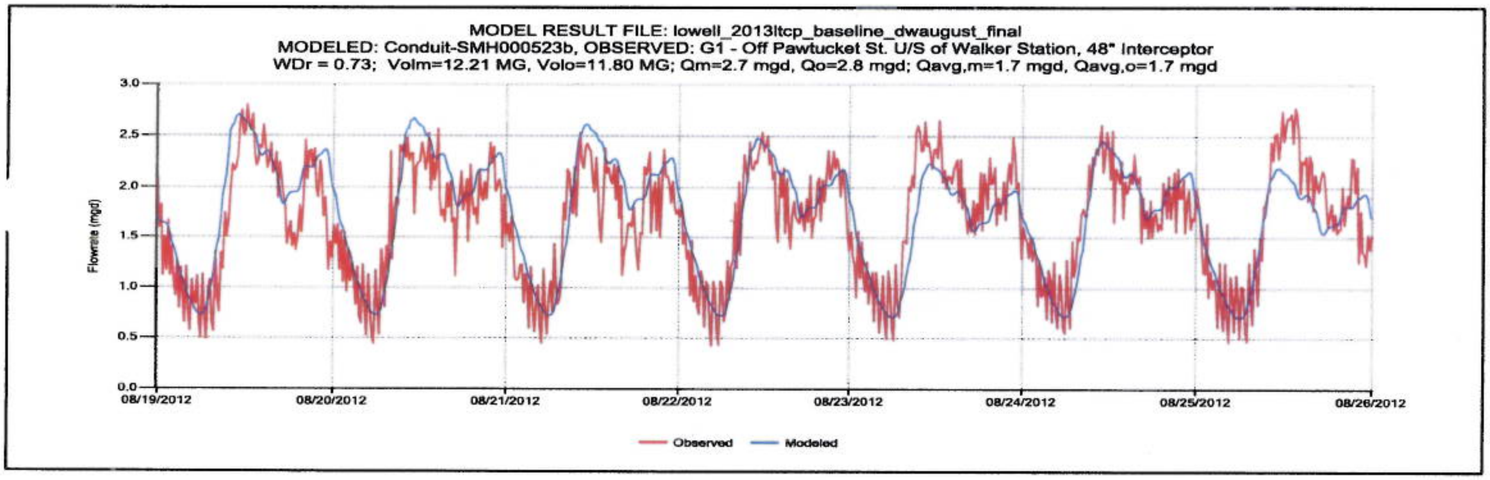
cc: File

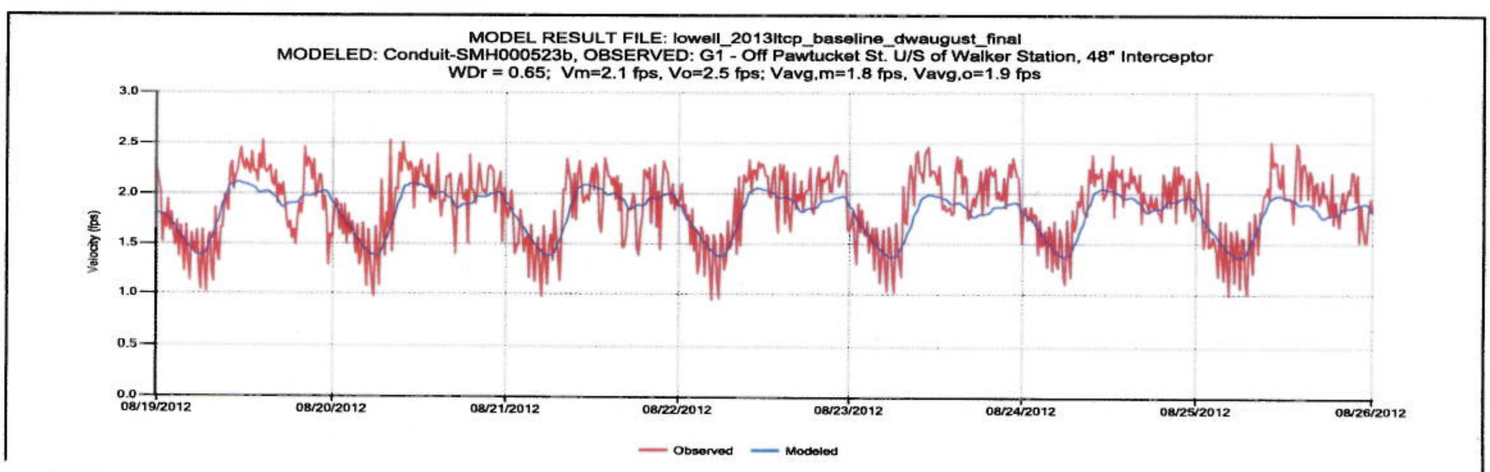
# Attachment 1

## August Dry Weather Period

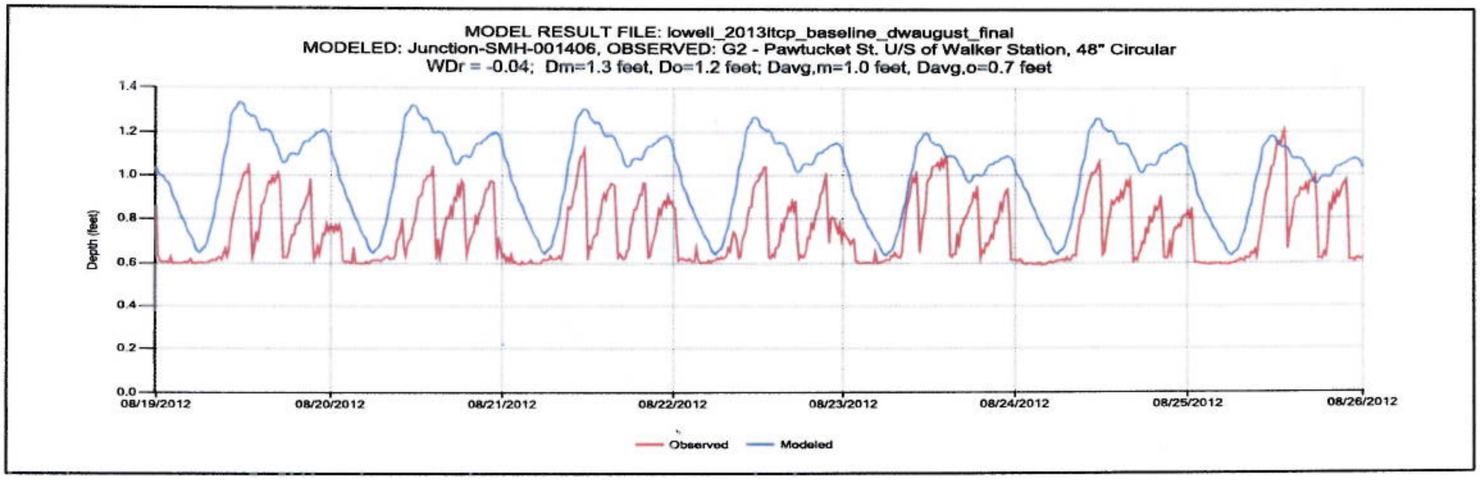
### G1-Fall Dry Period

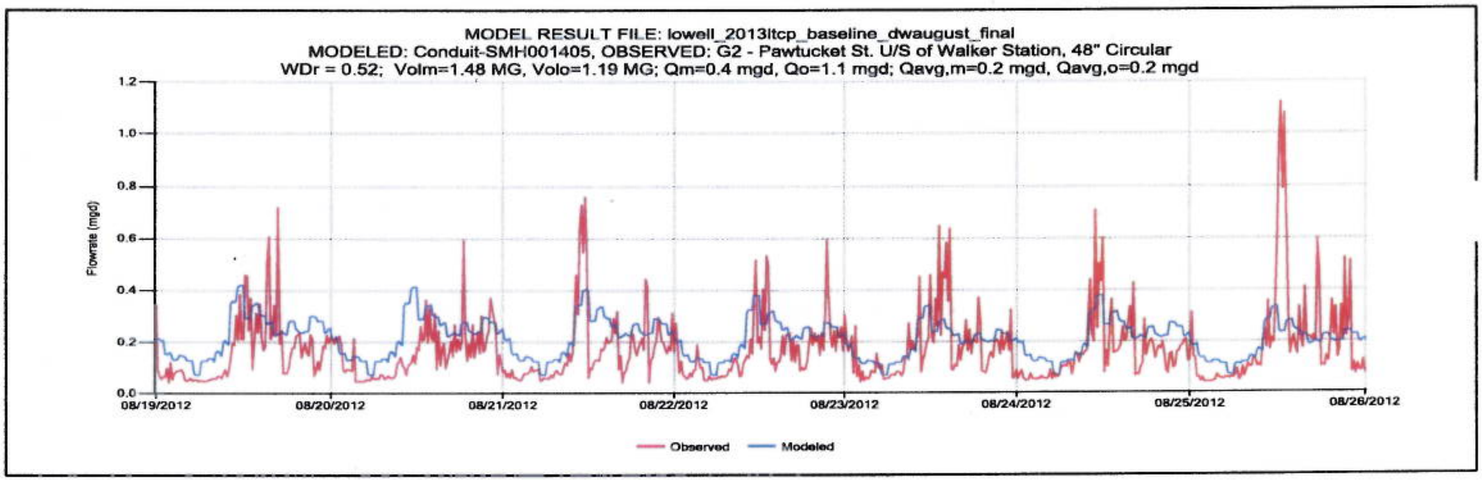


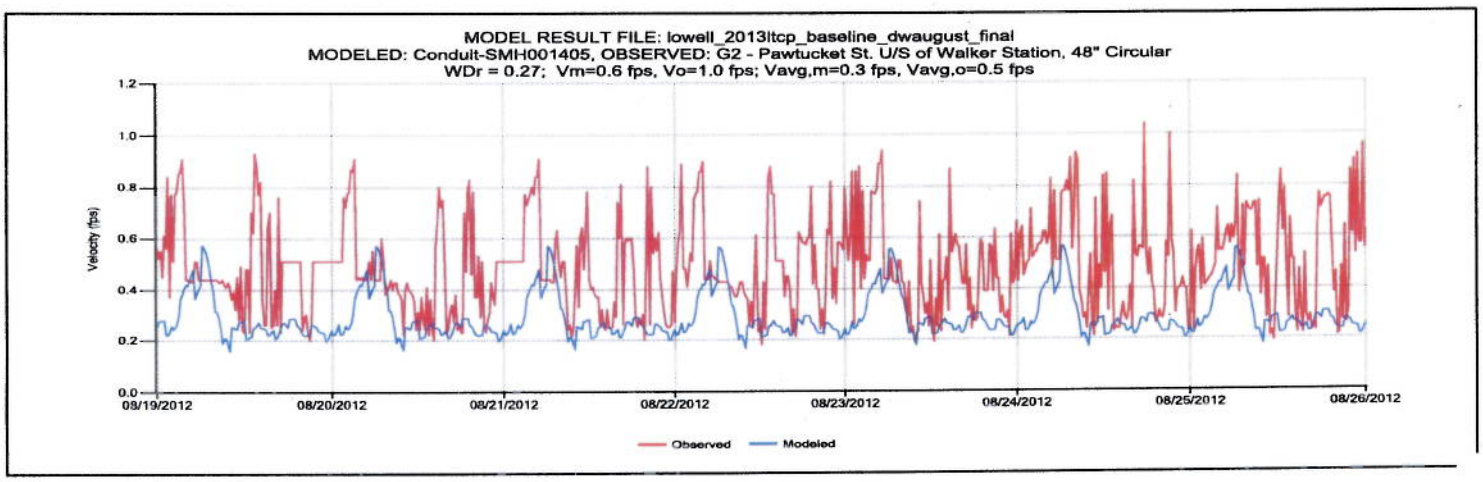



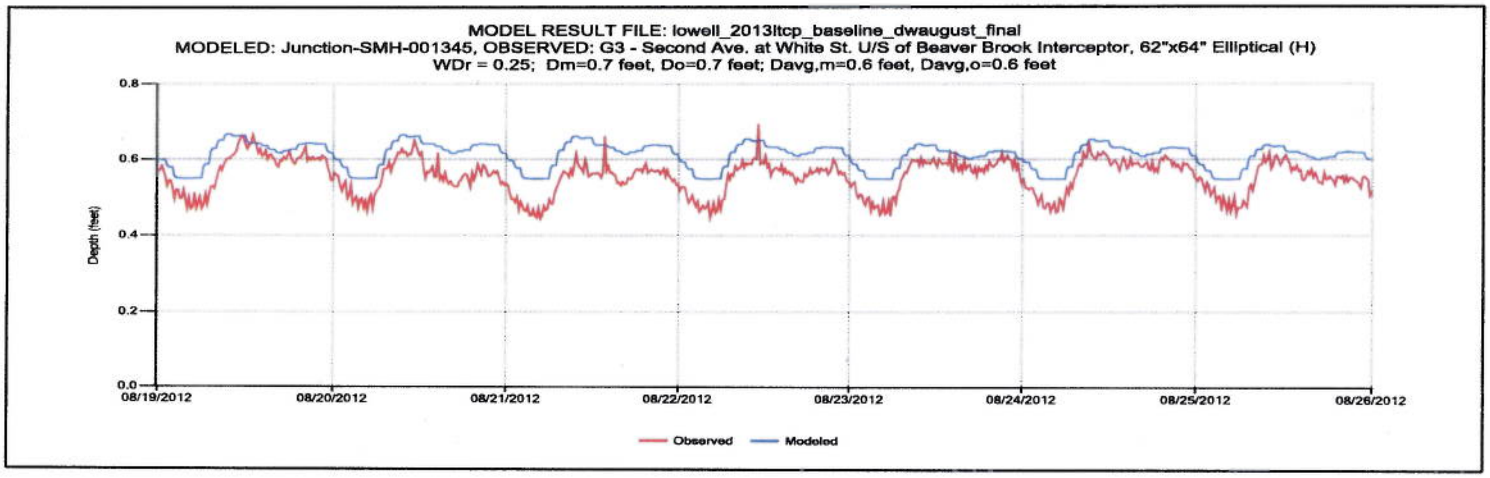
# G2-Fall Dry Period

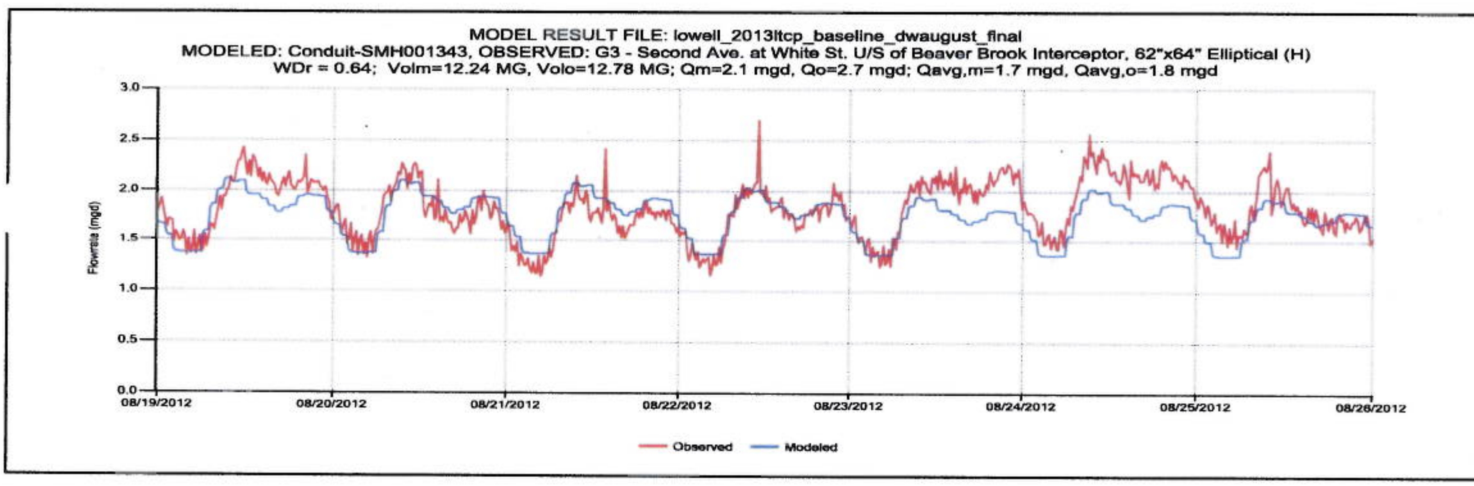


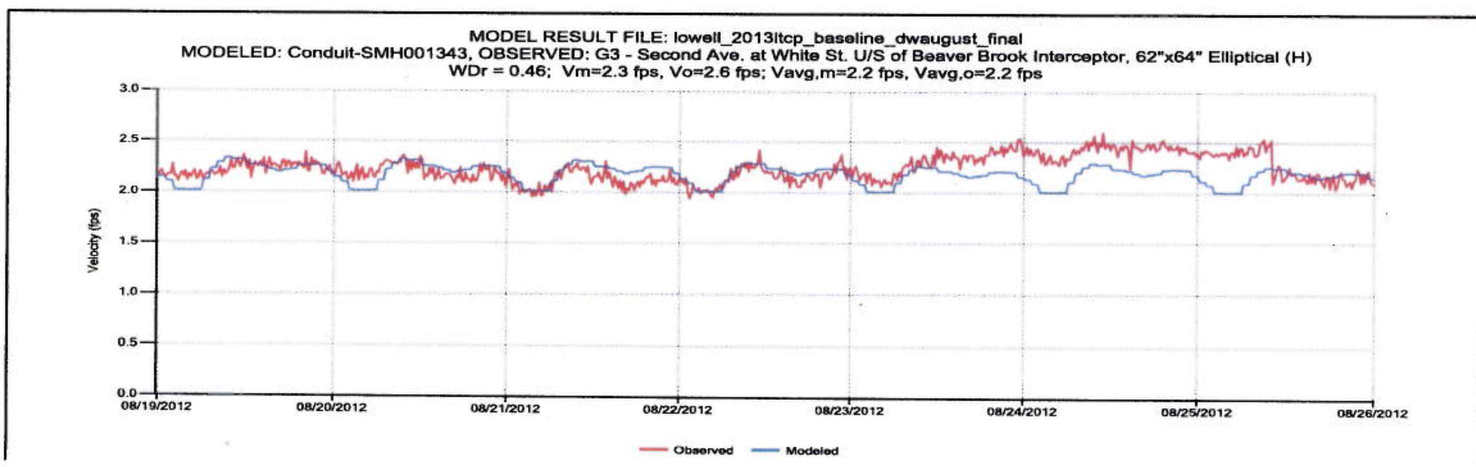



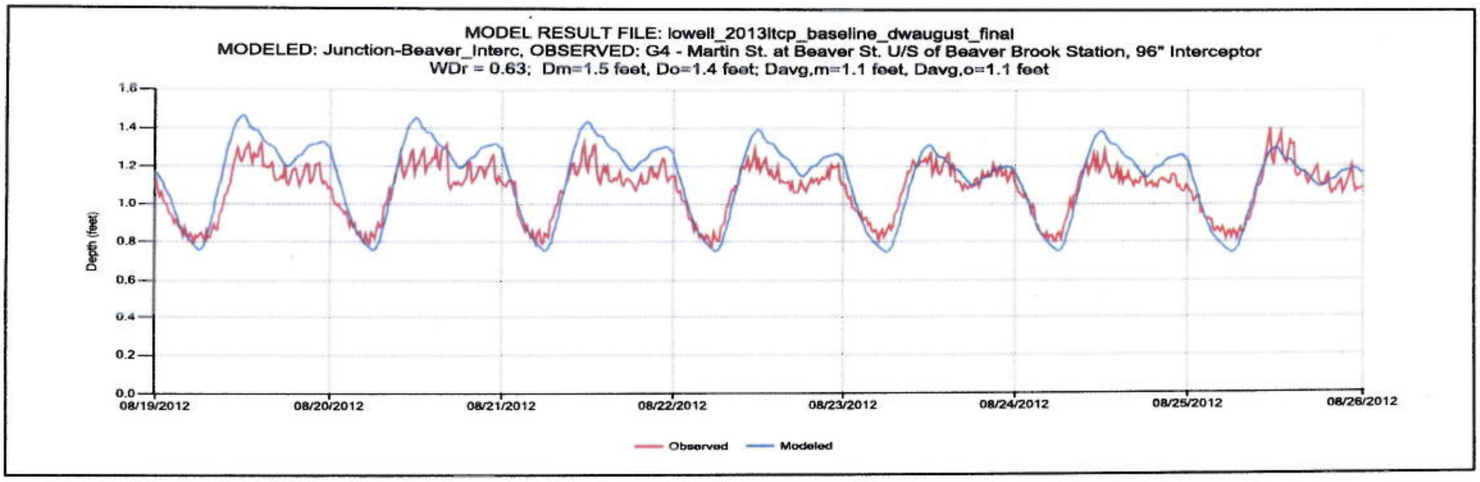
# G3-Fall Dry Period

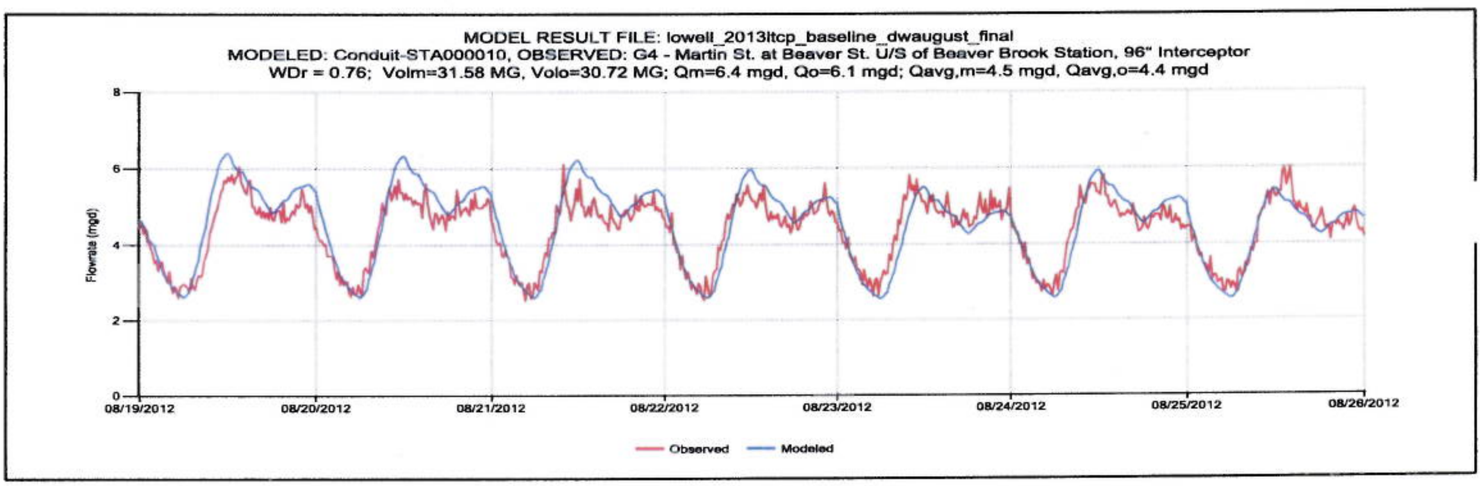


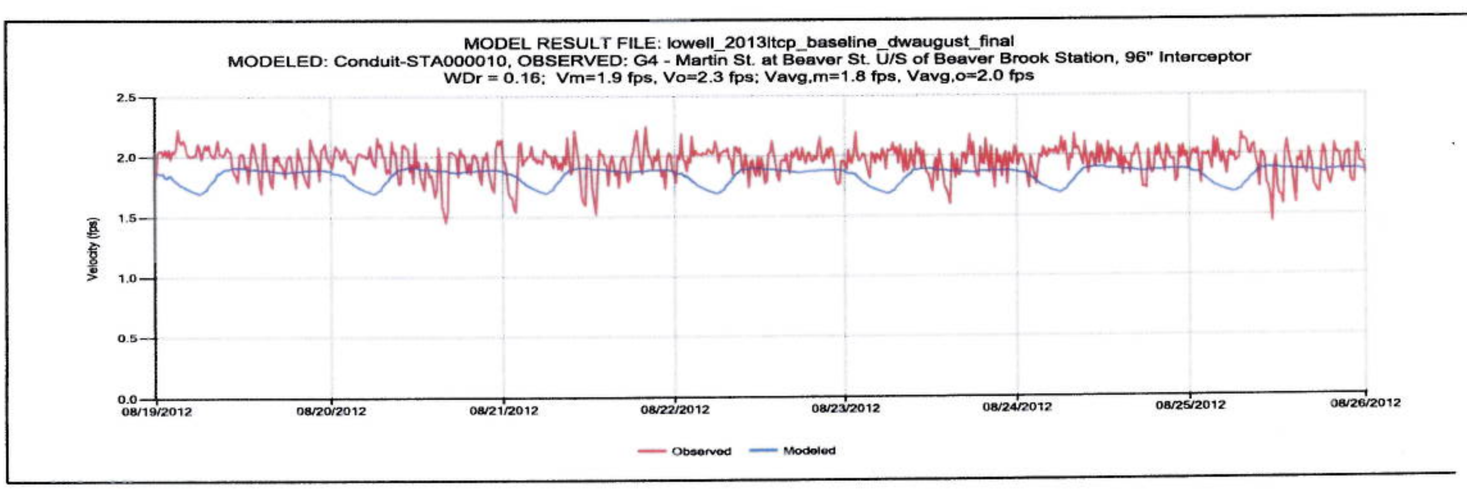



# G4-Fall Dry Period



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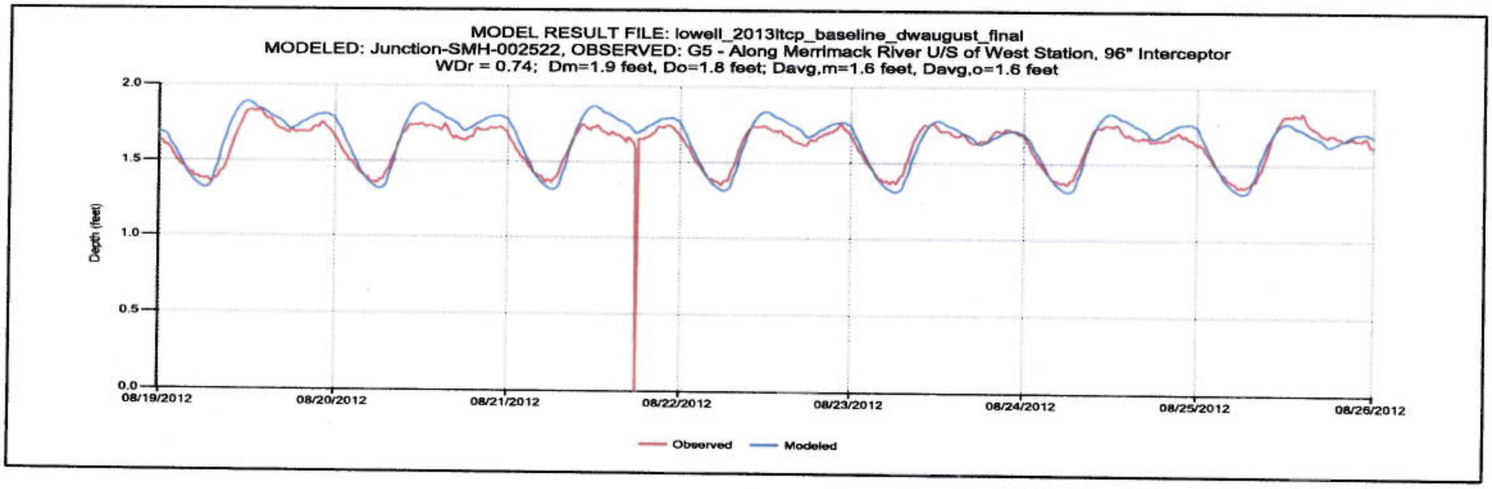


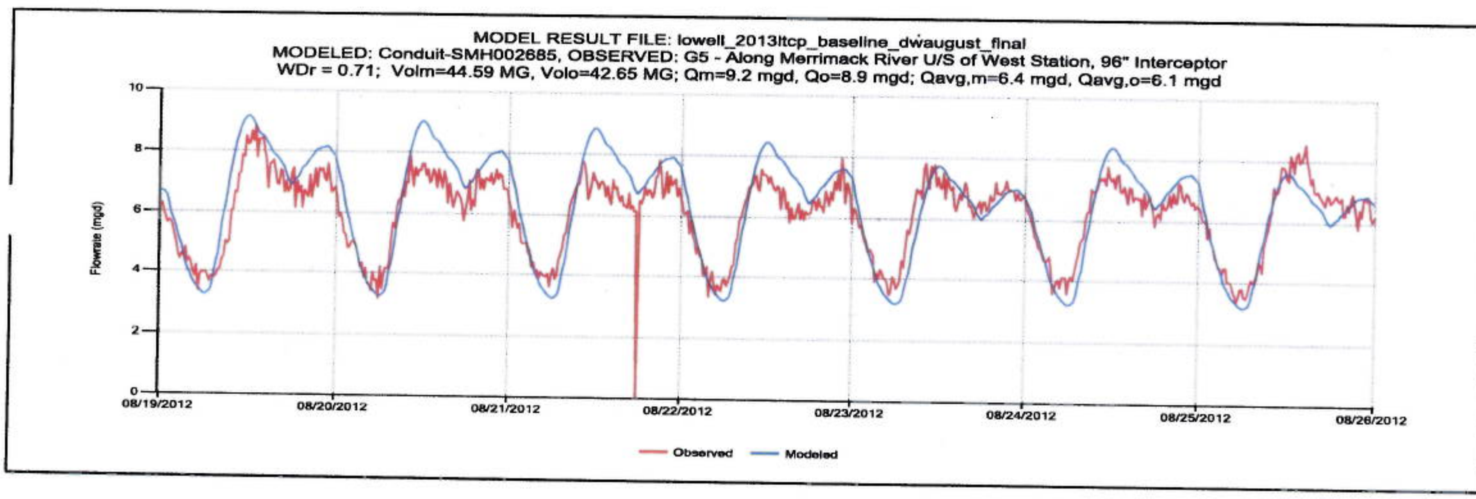


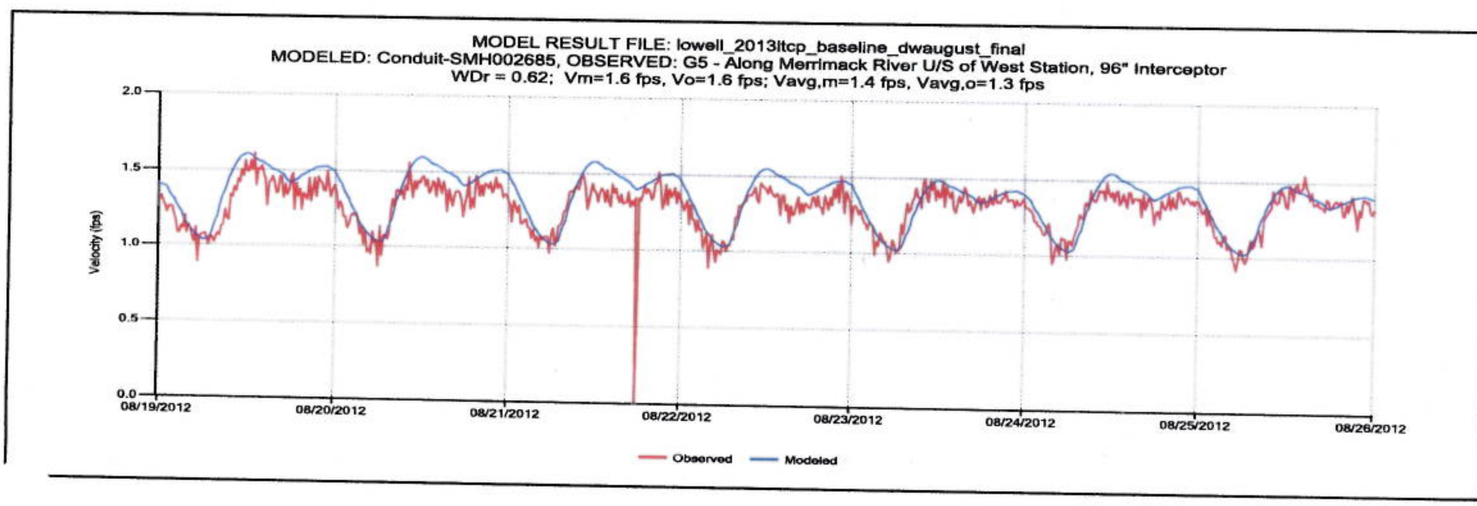

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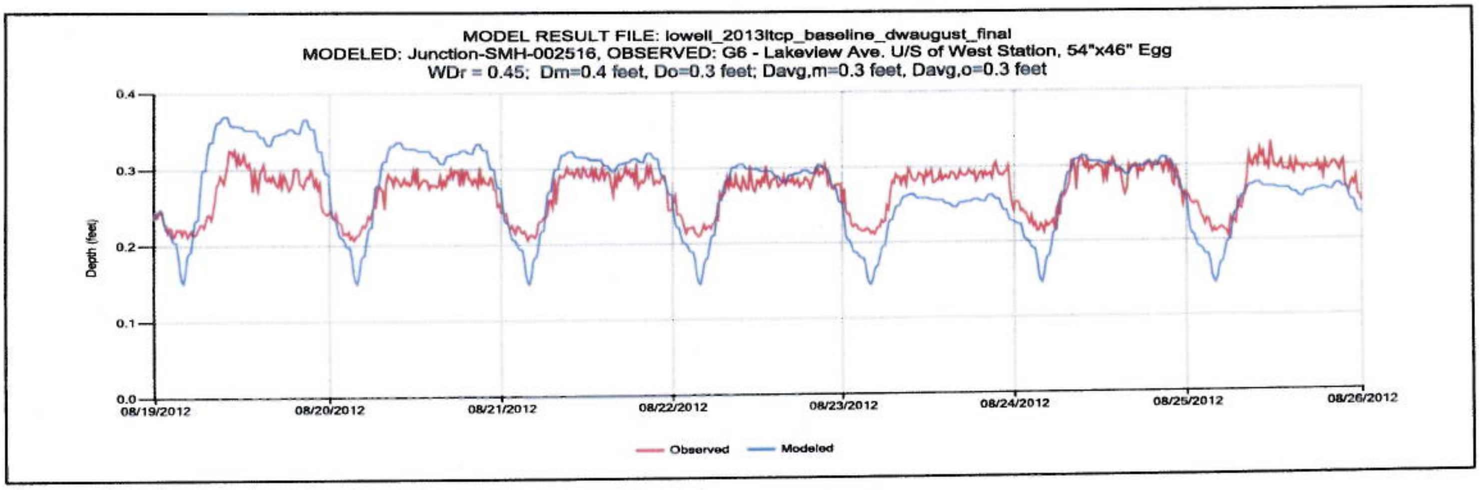


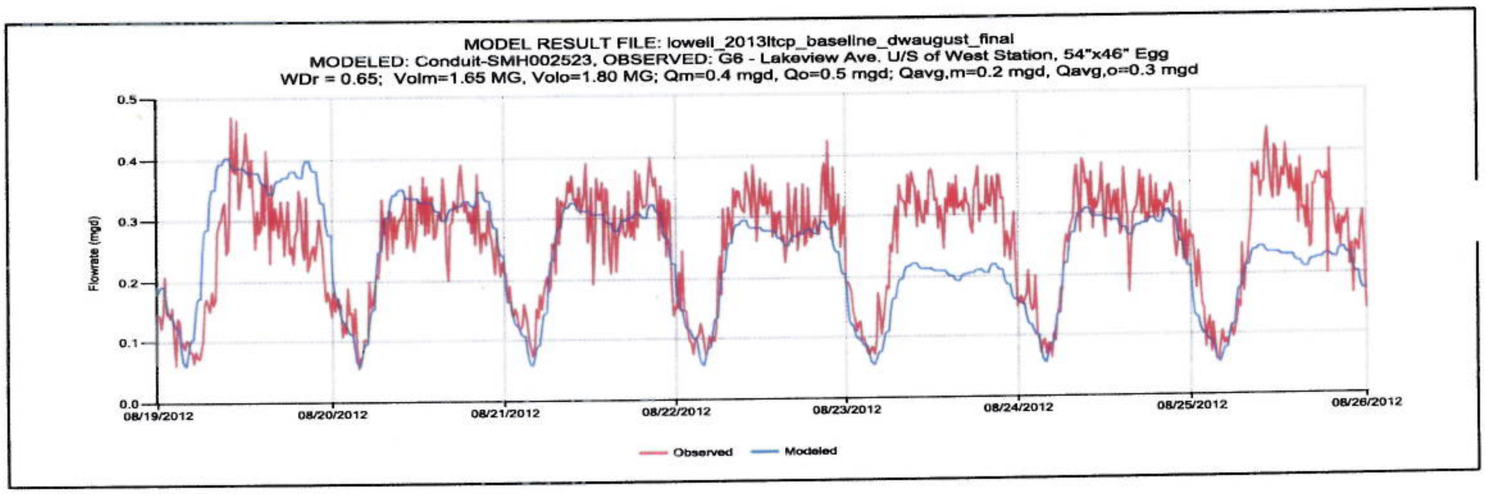


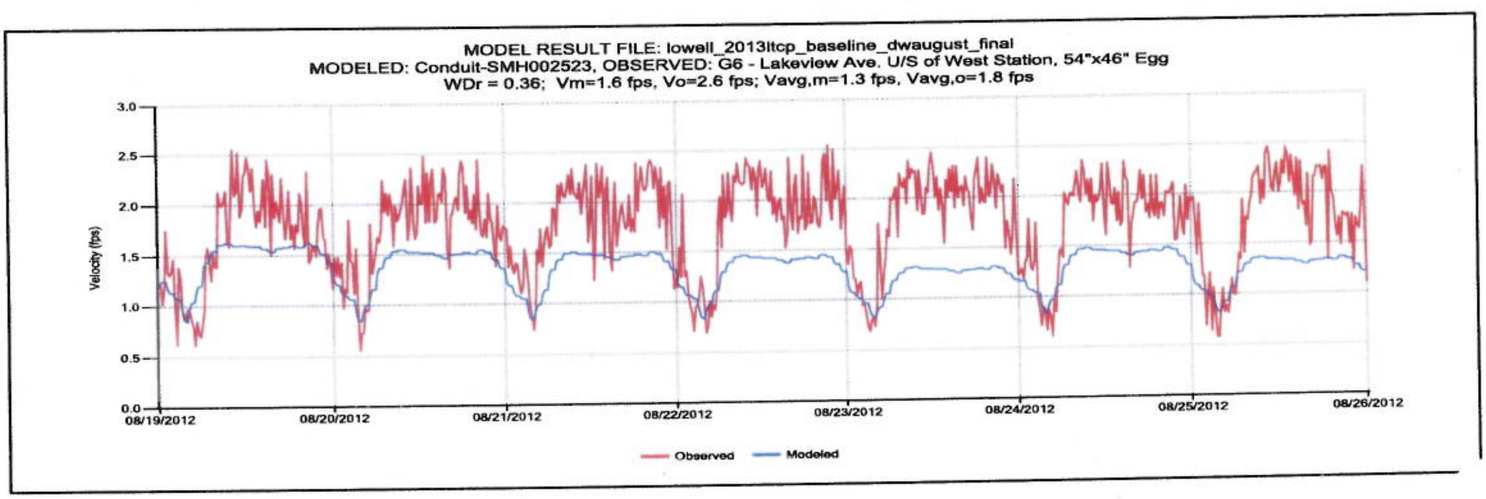

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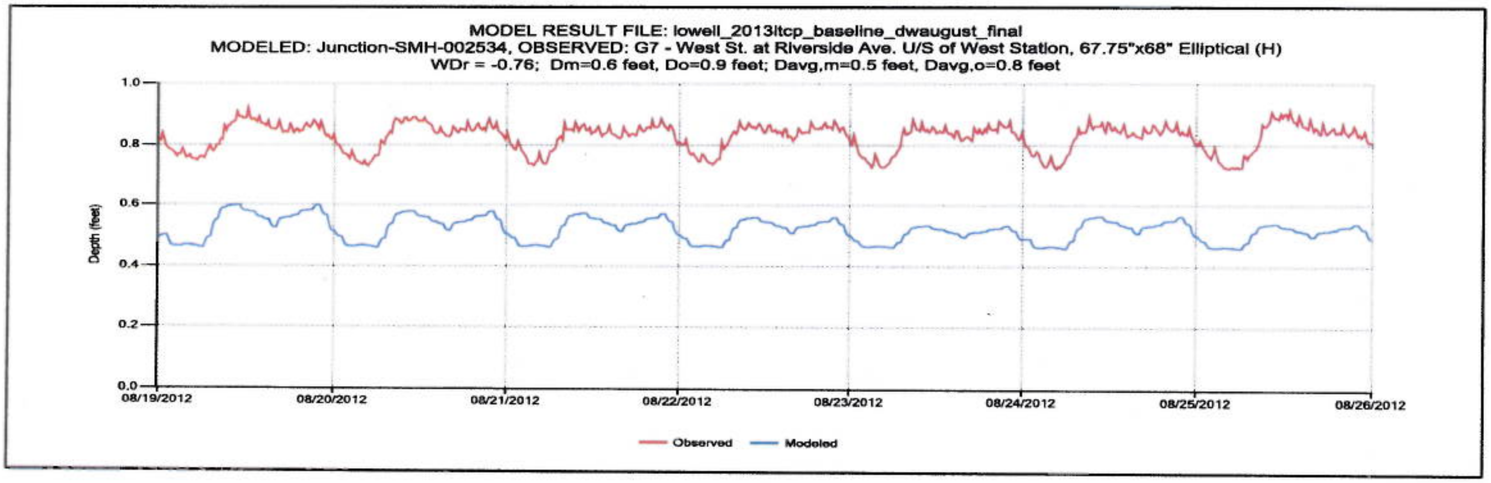
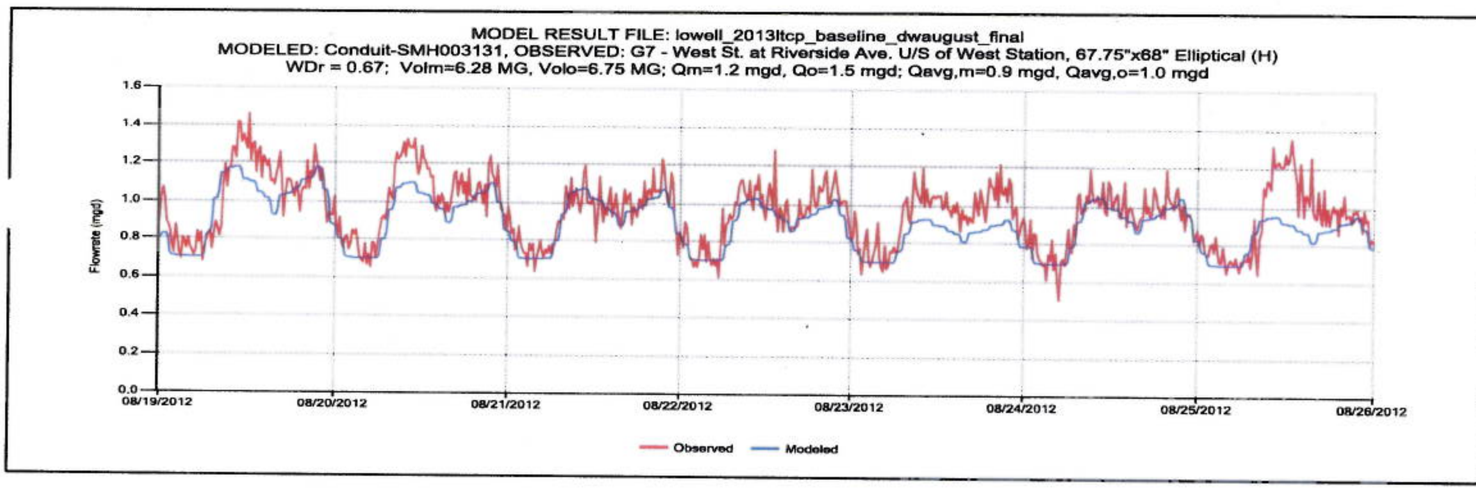
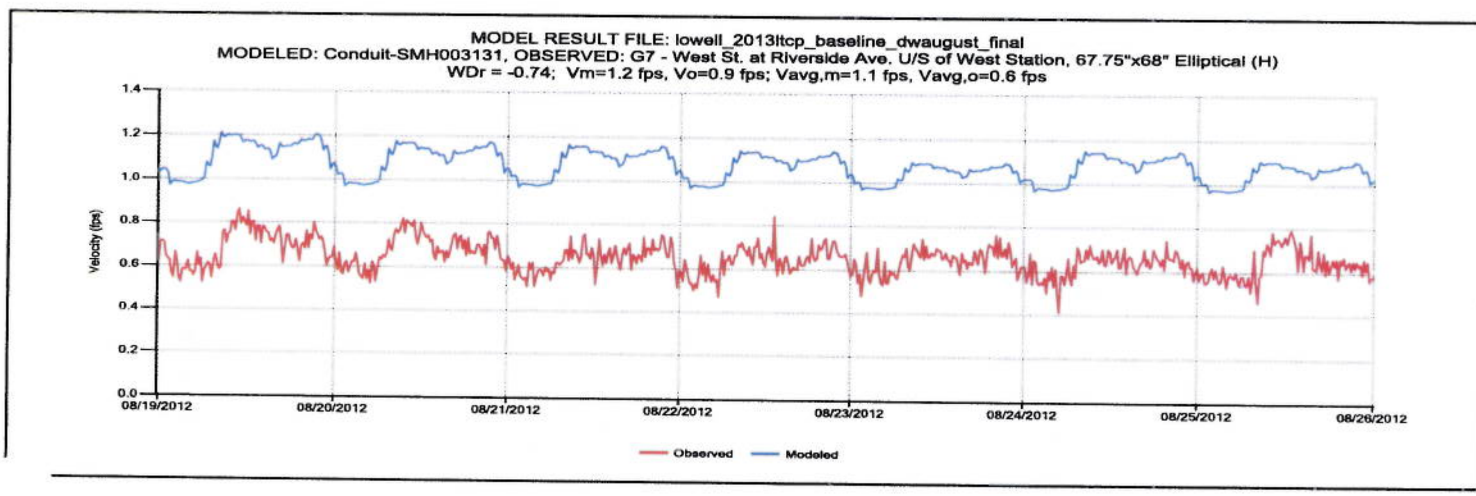
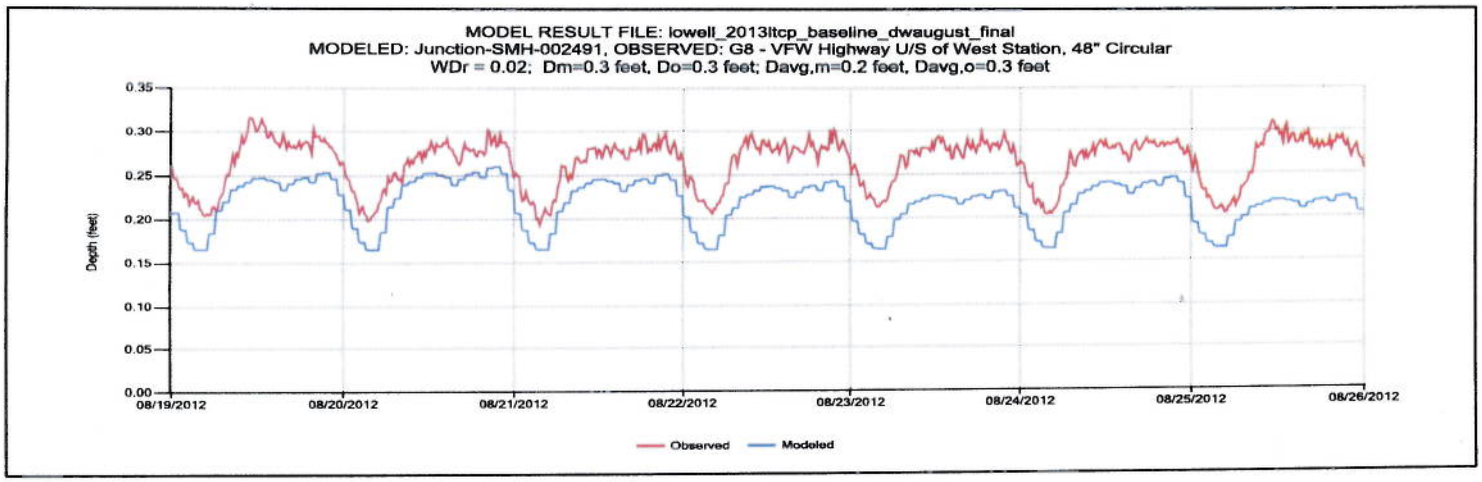
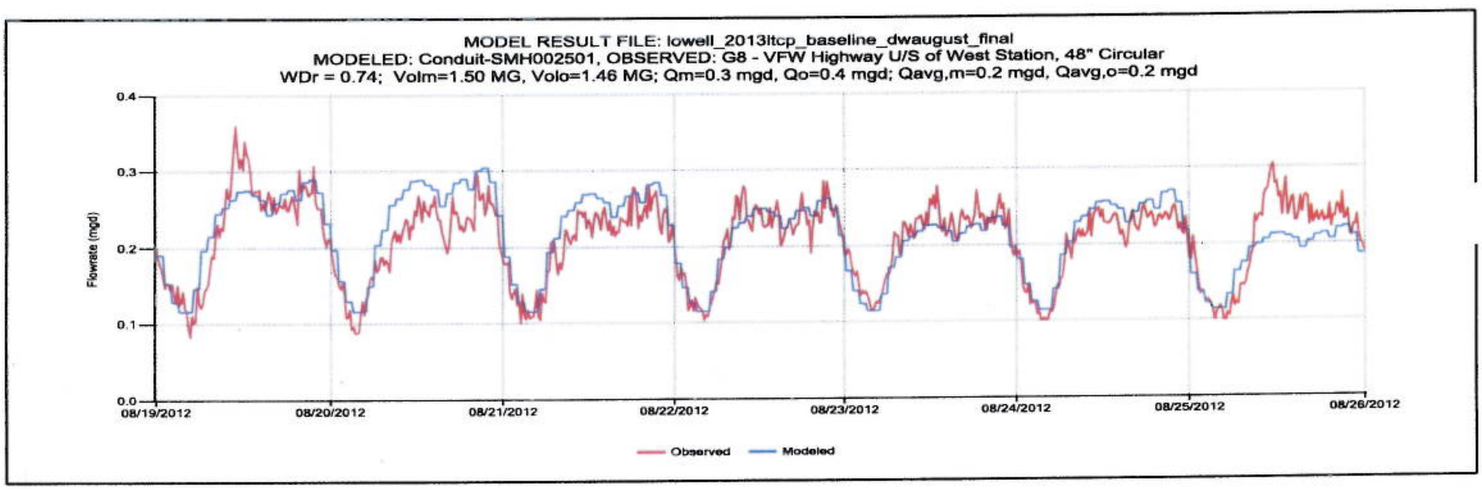


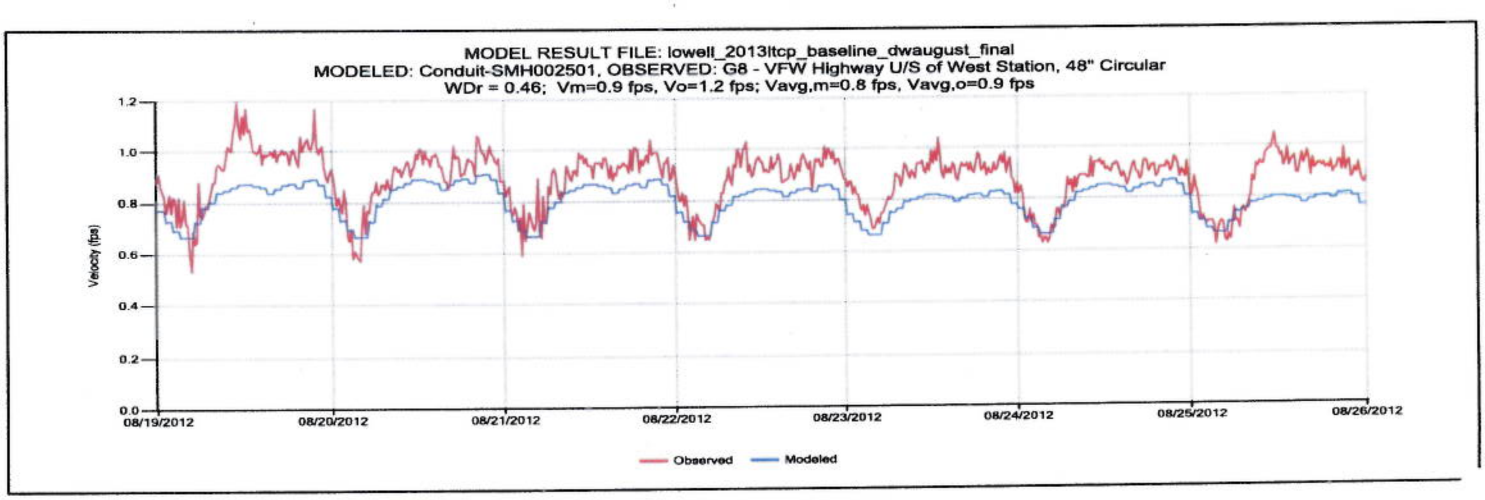



## G8-Fall Dry Period



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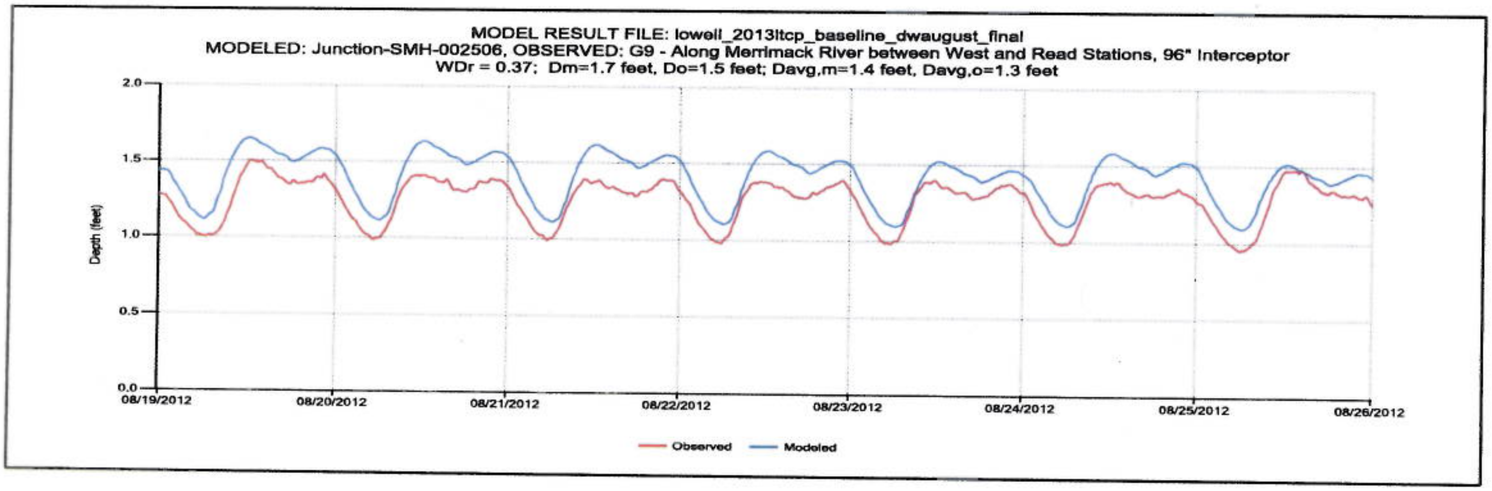


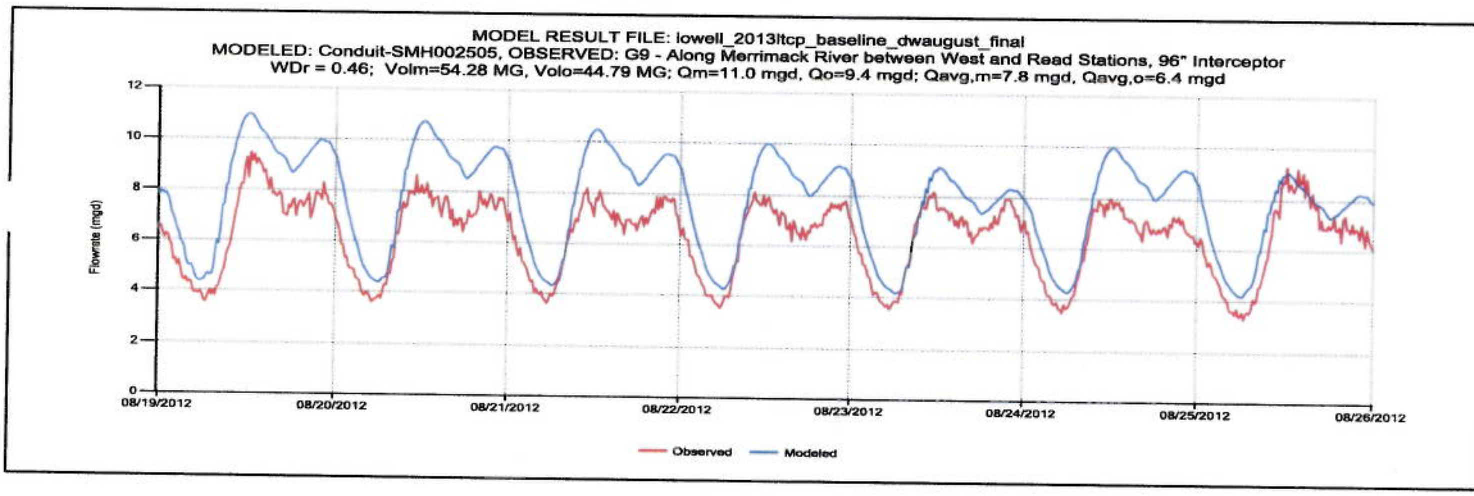


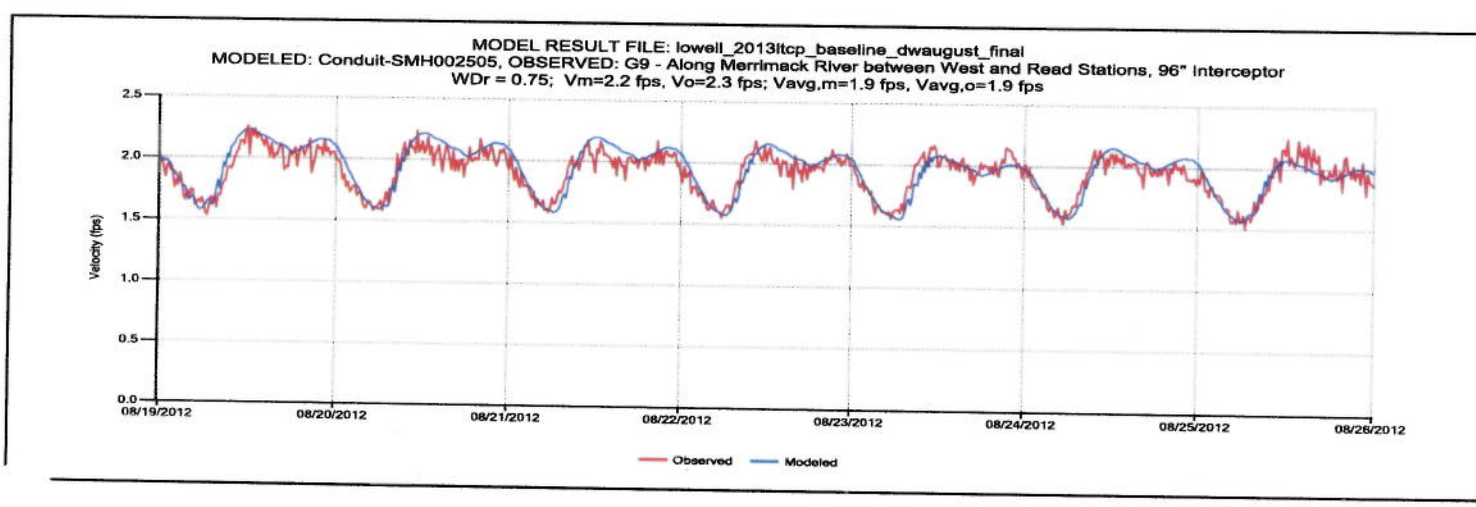

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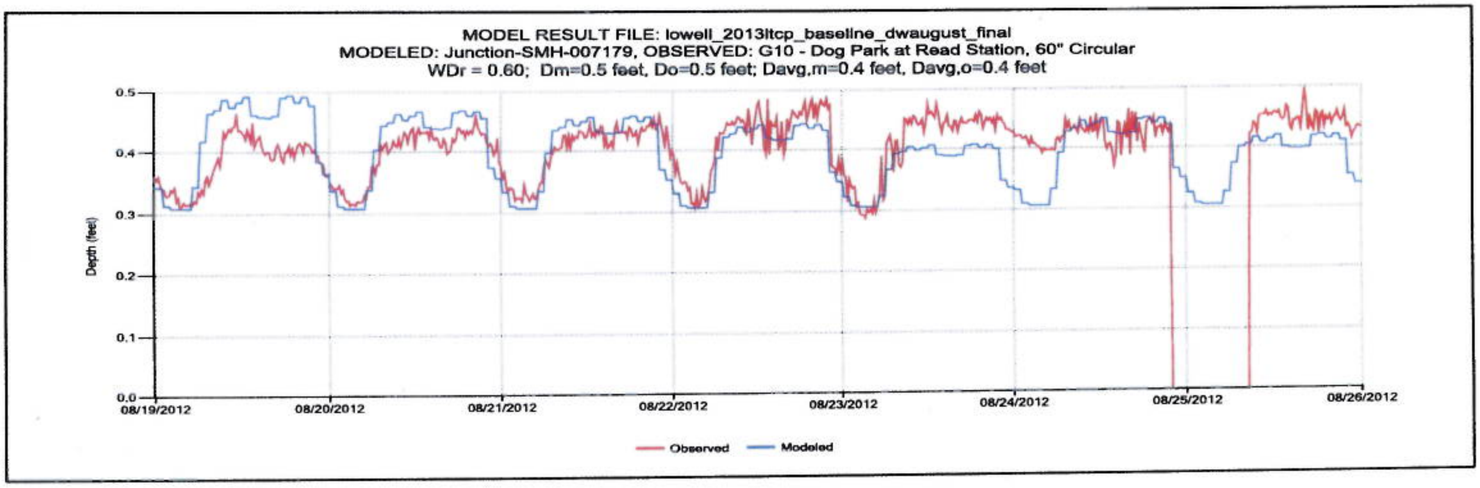


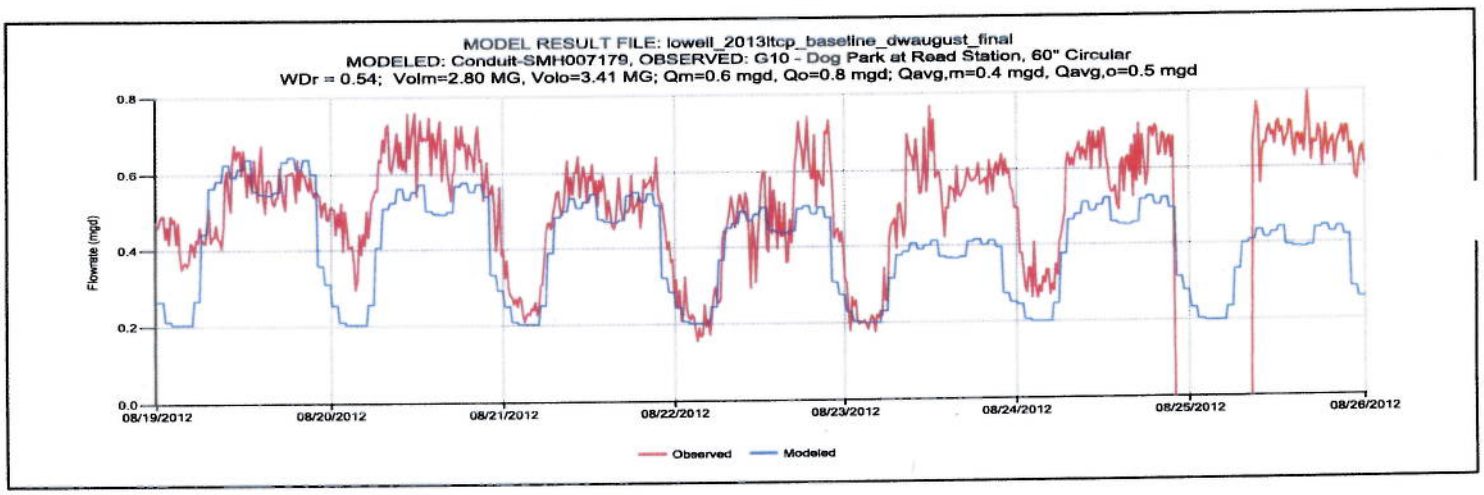


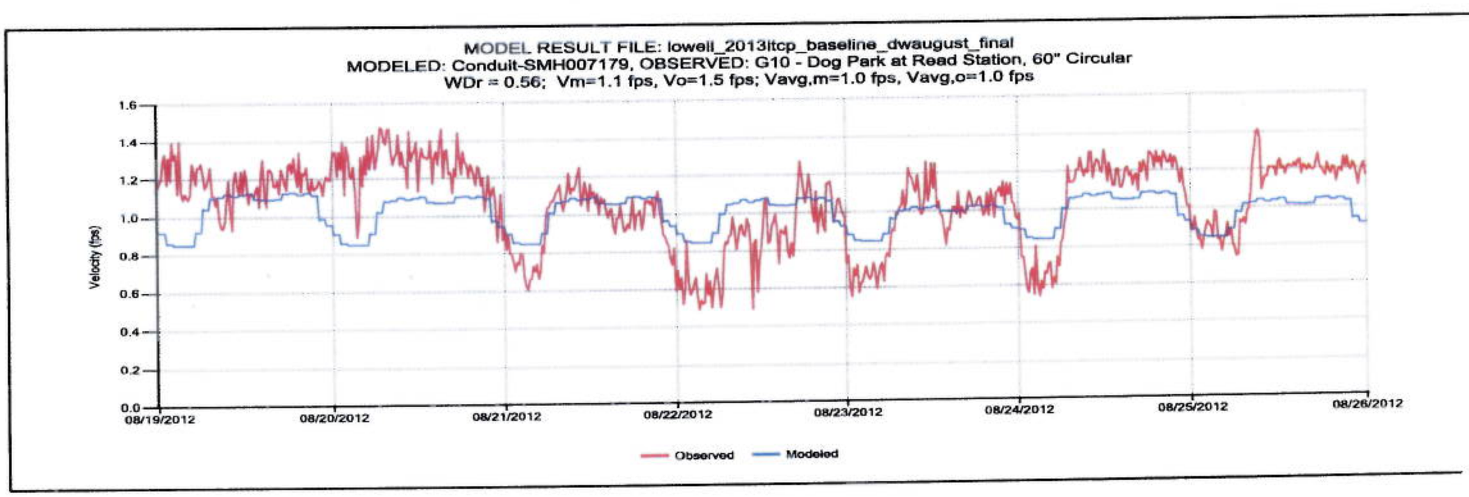

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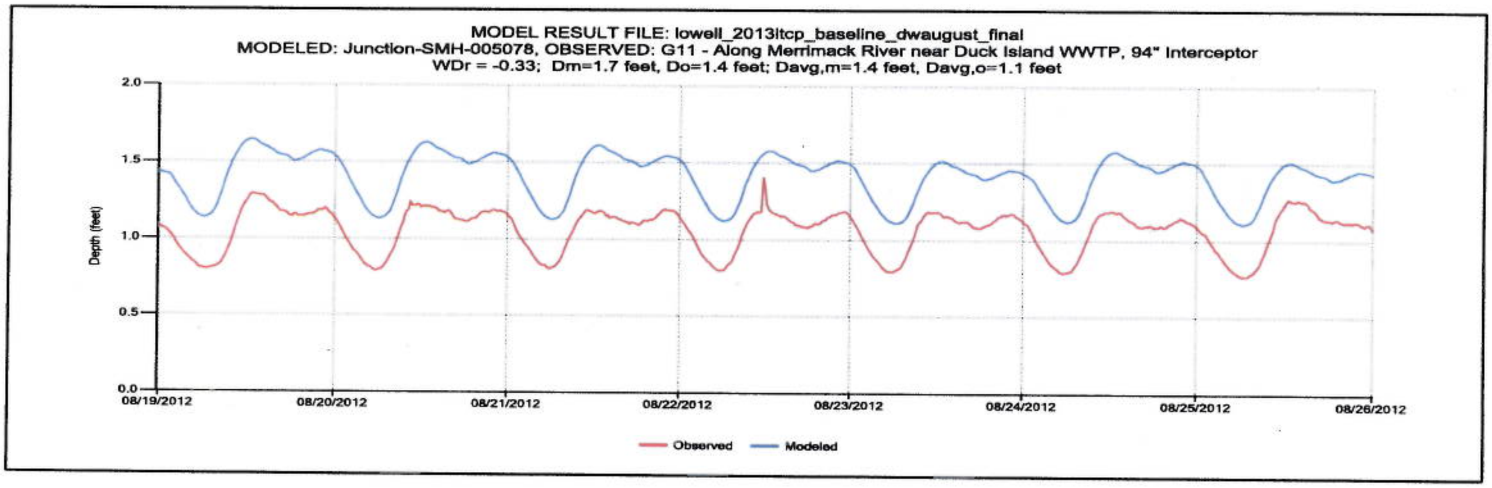


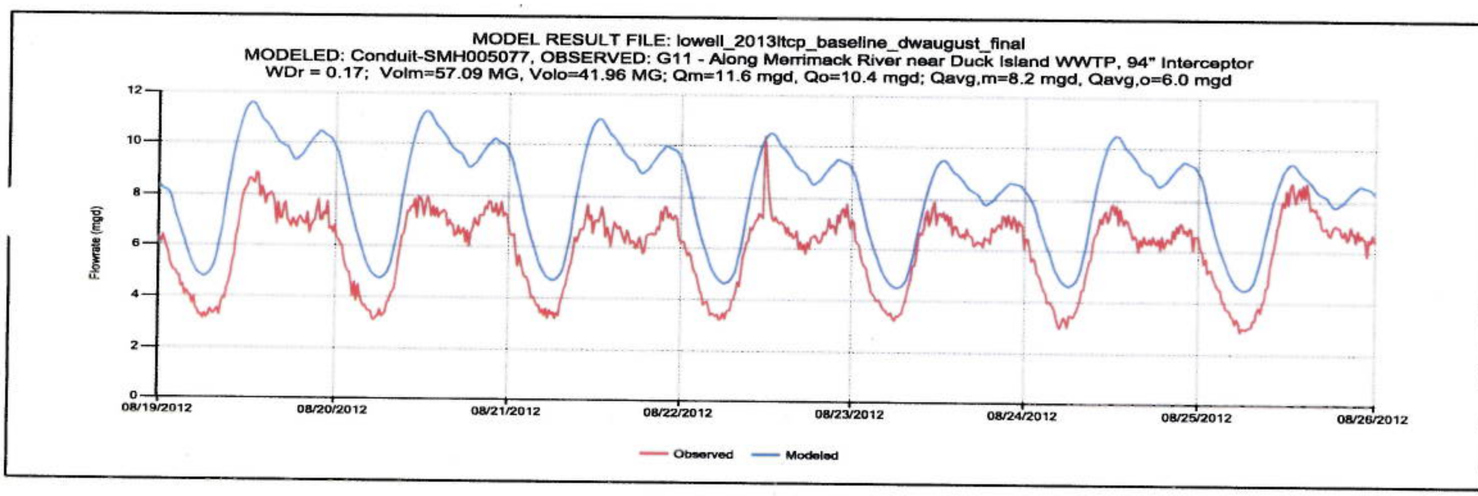


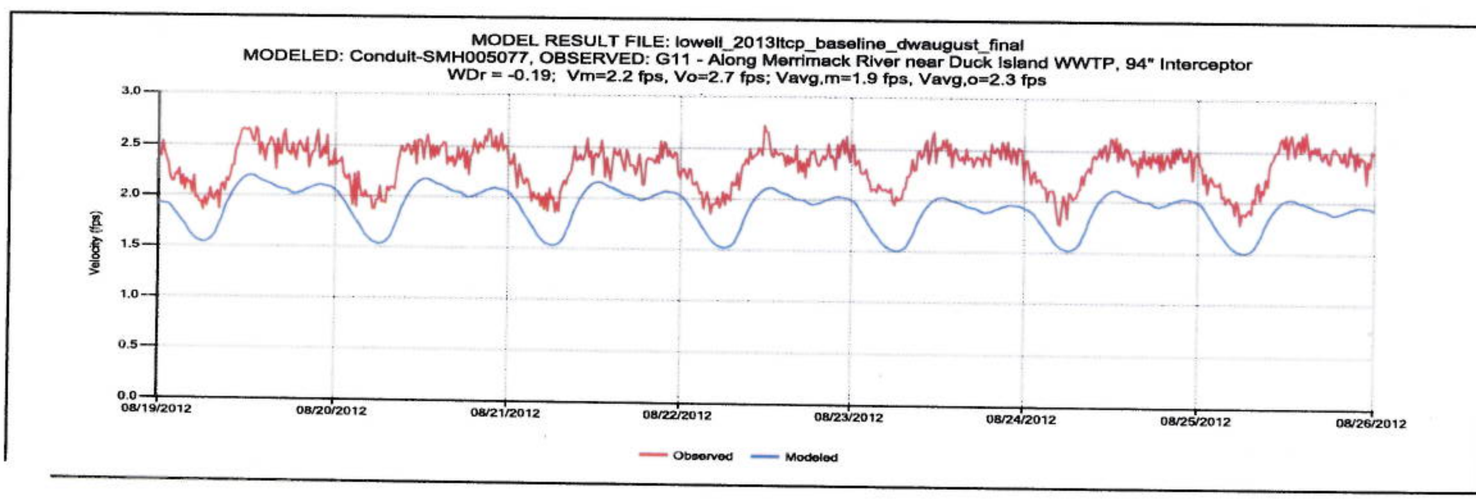

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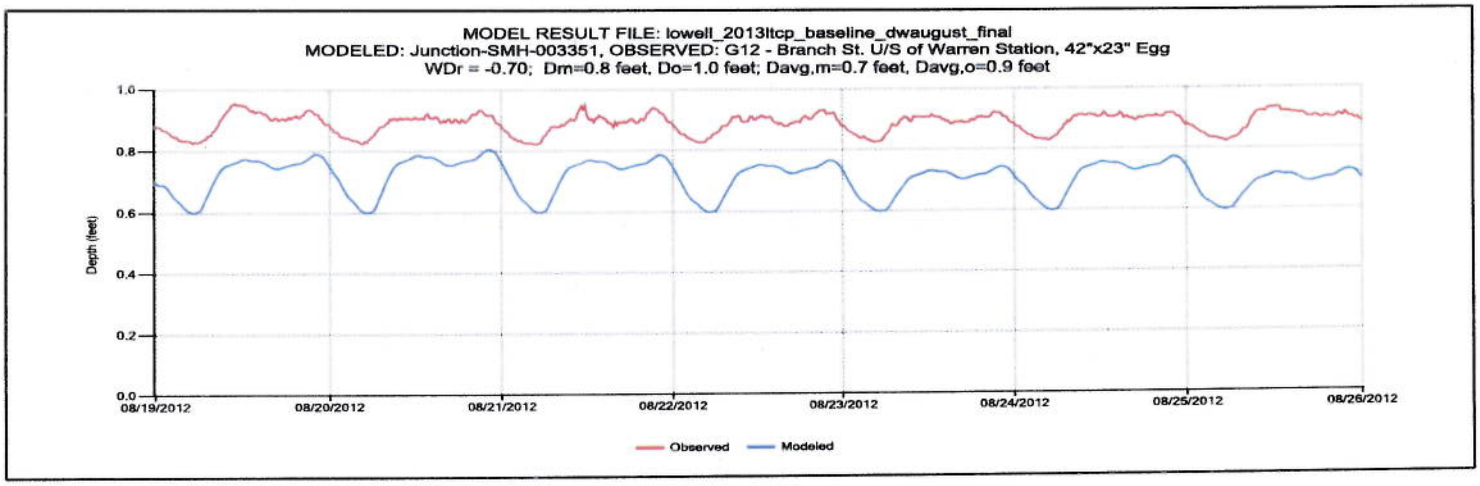


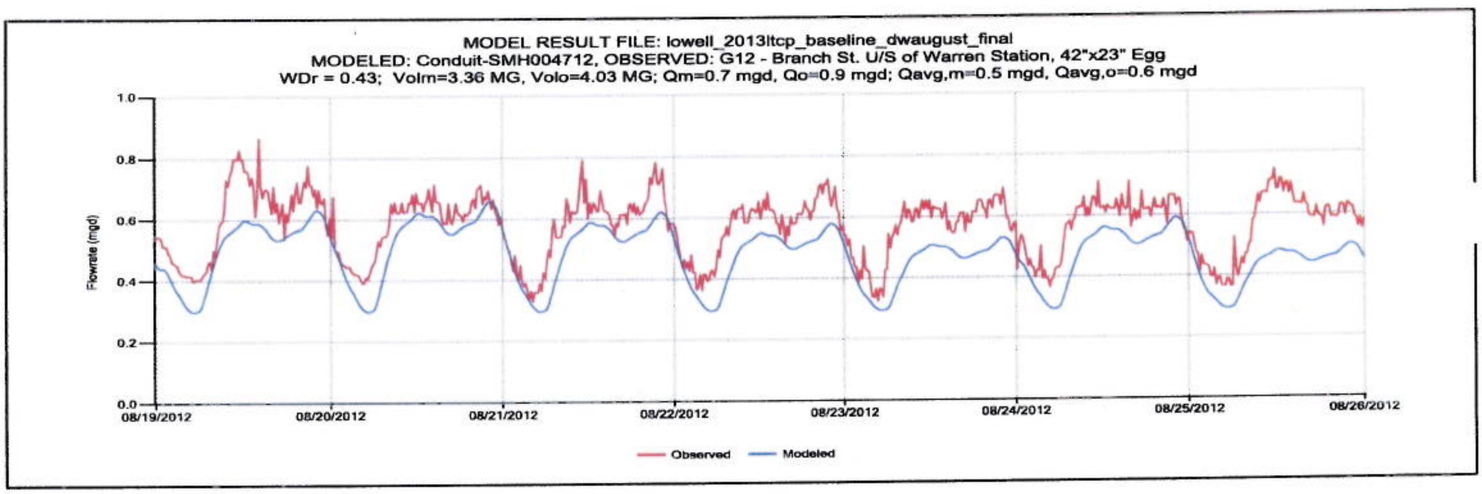


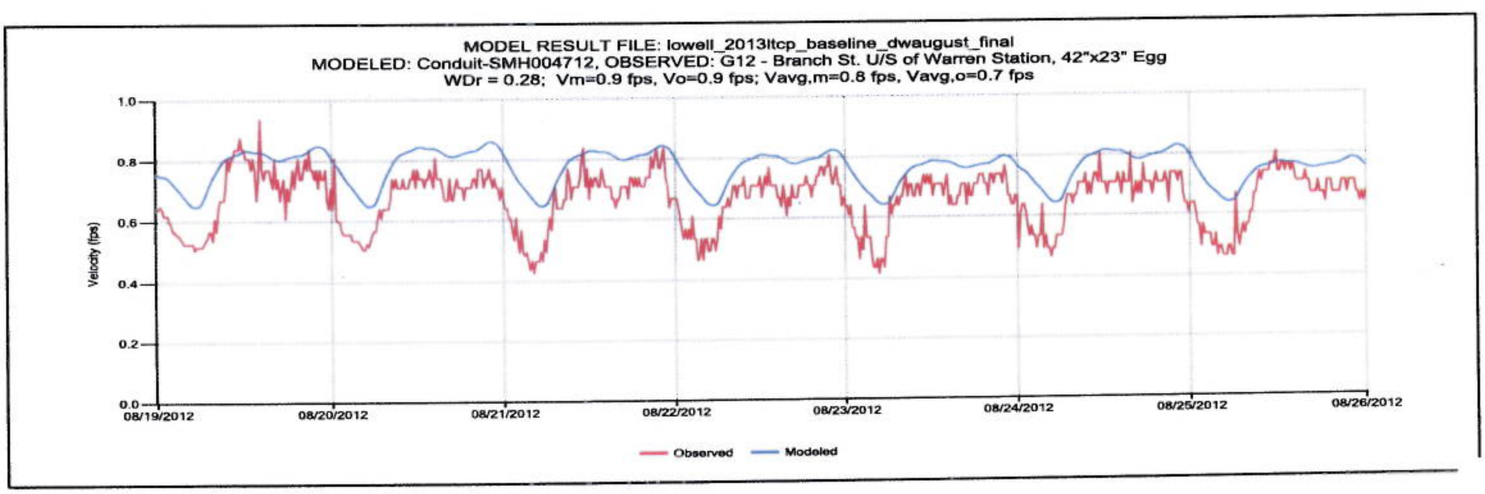

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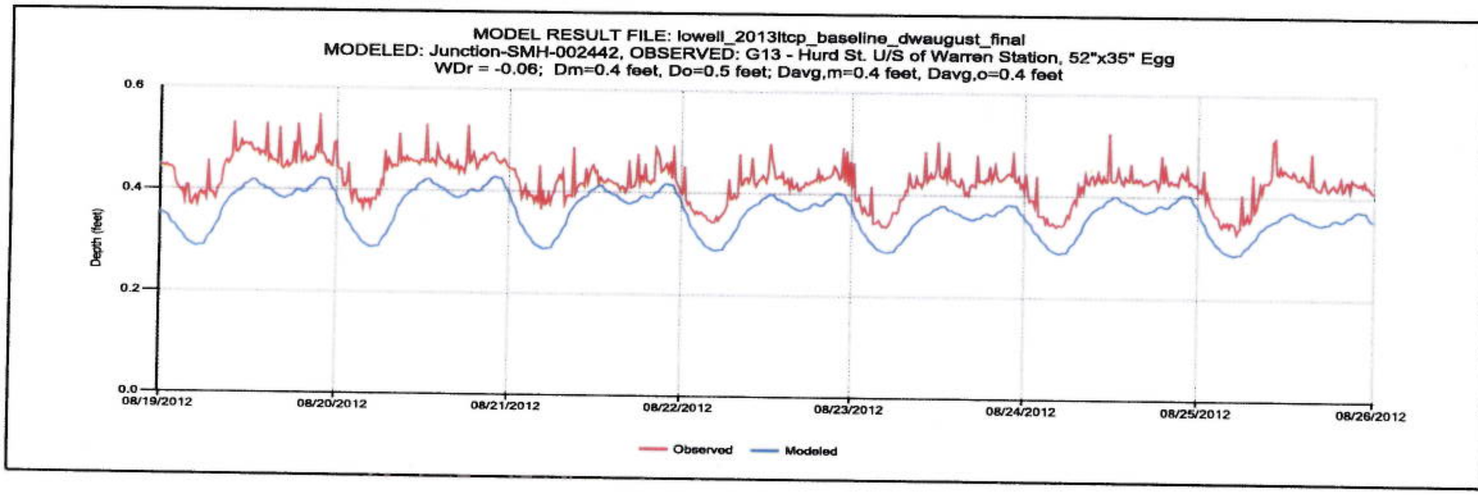


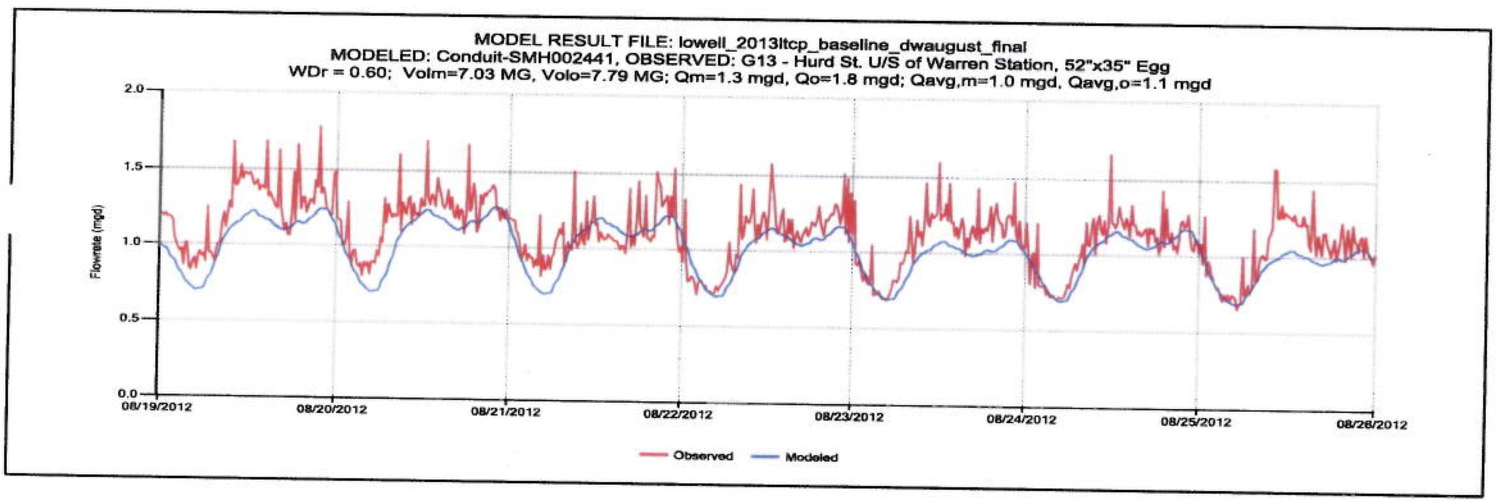


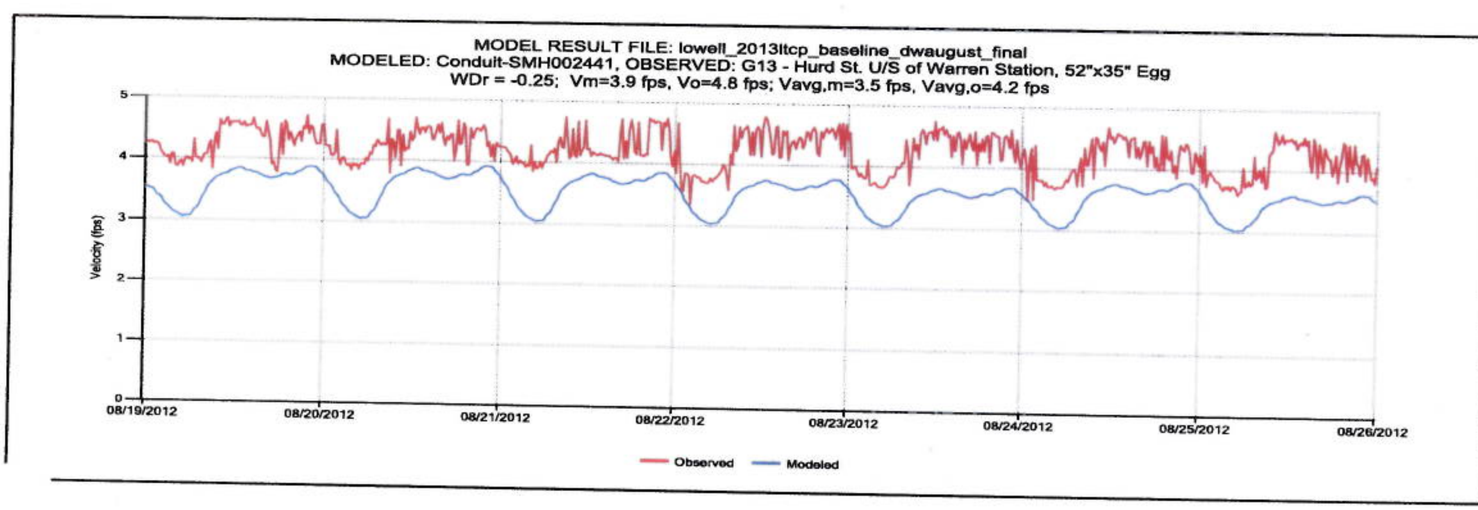

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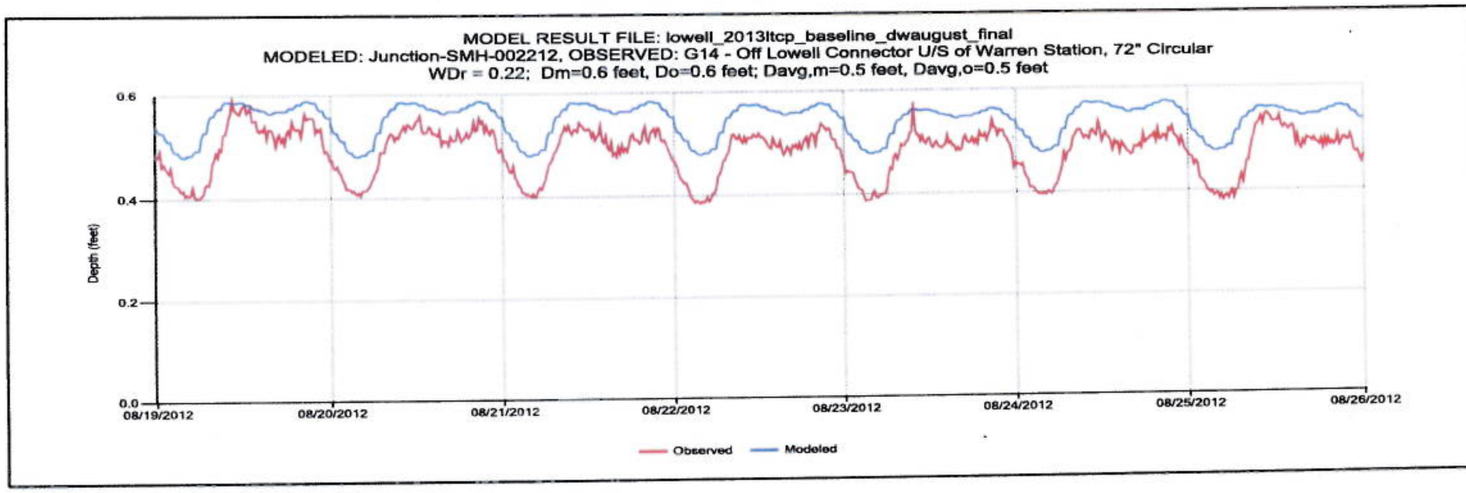


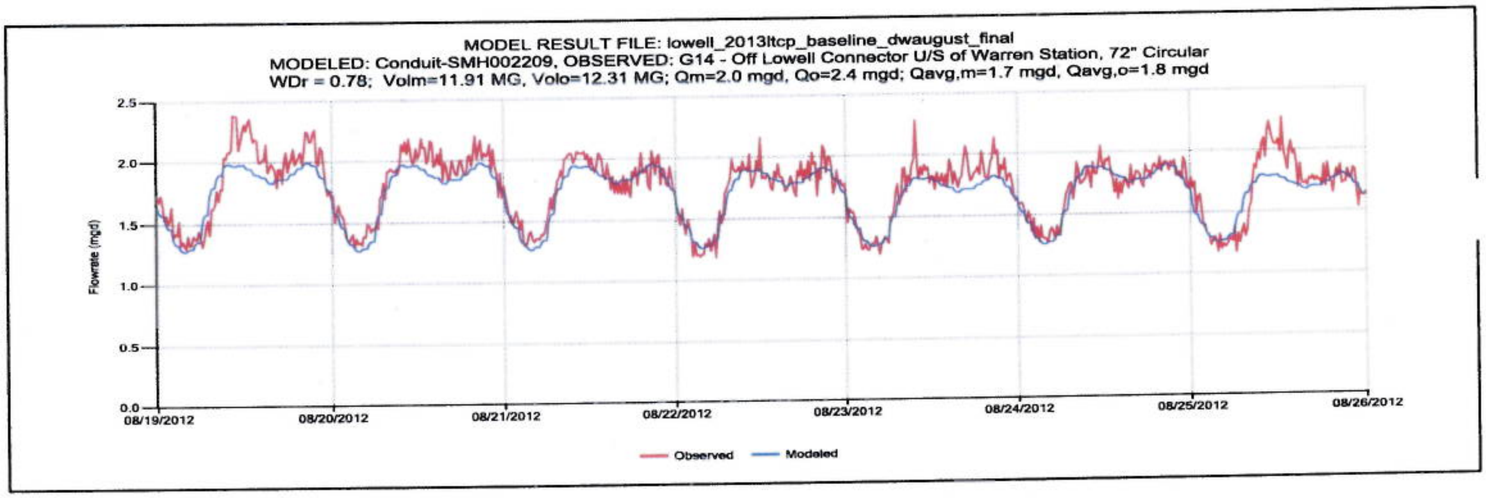


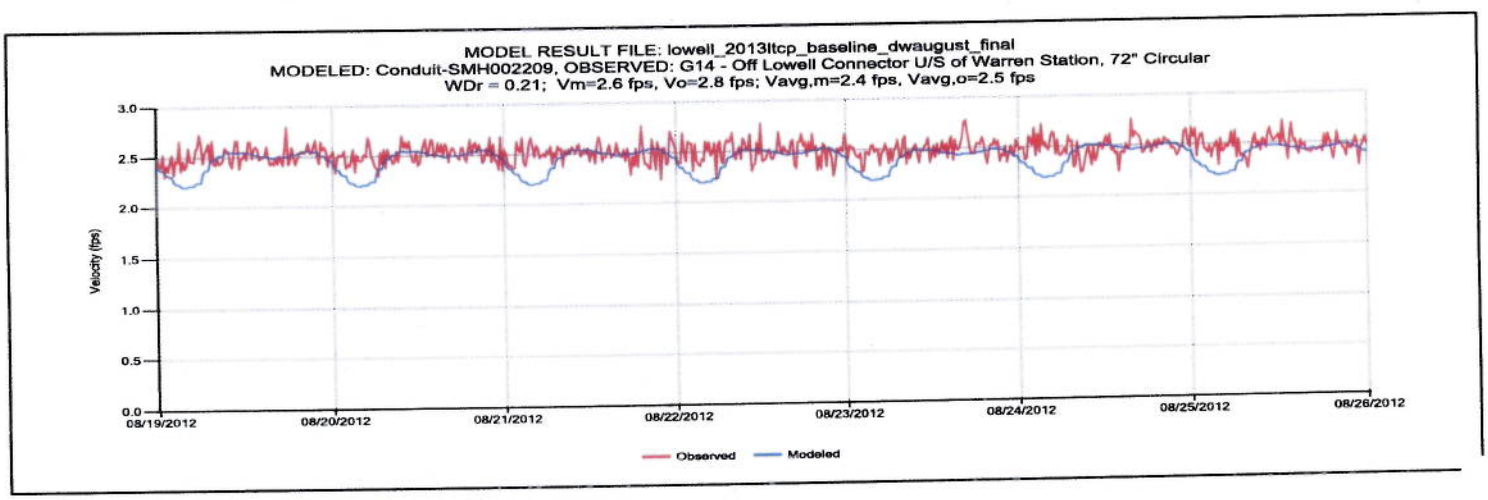

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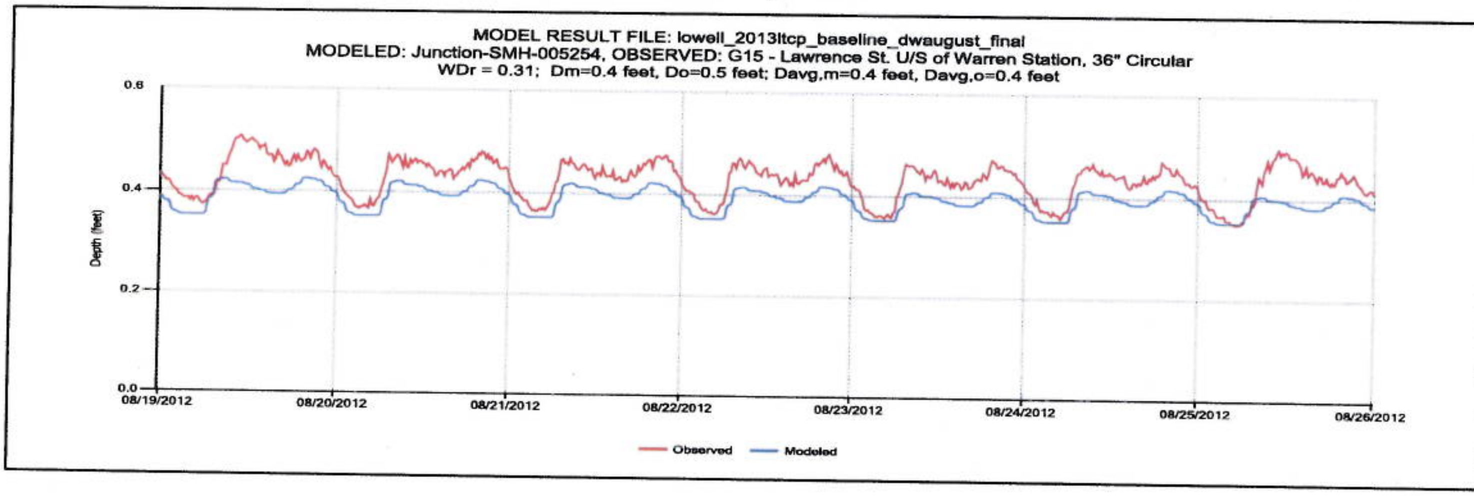


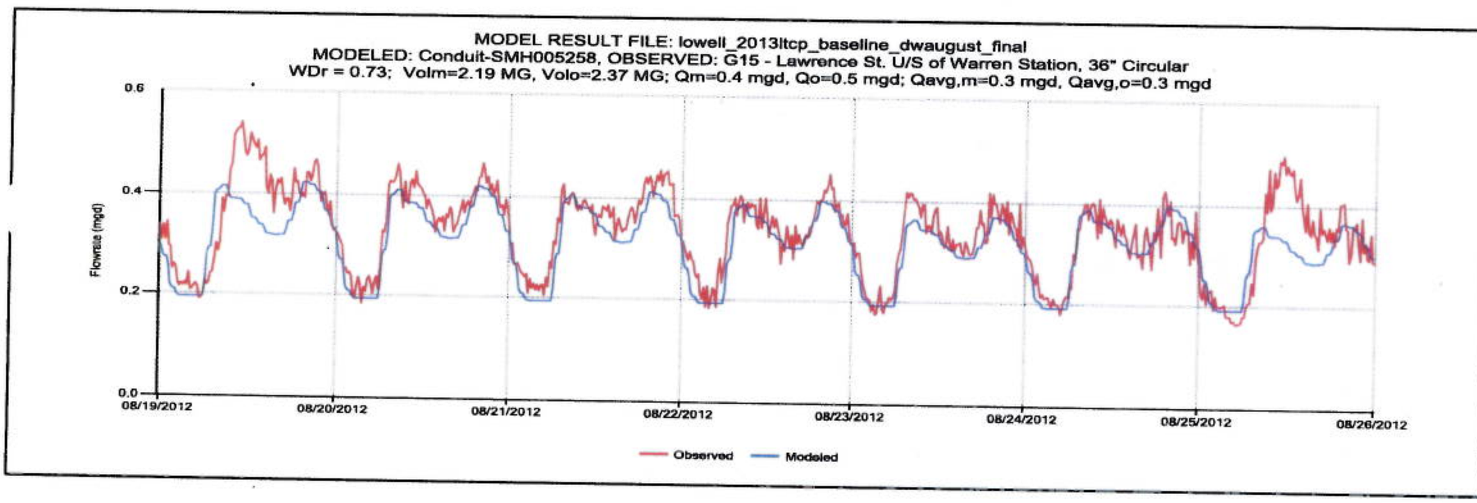


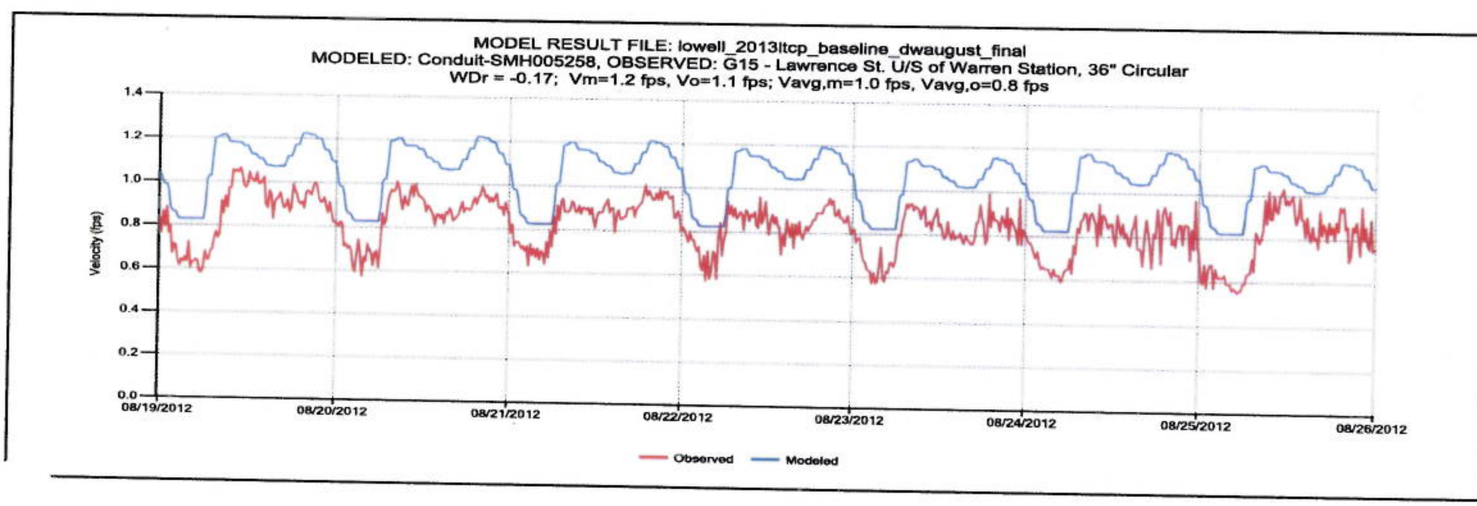

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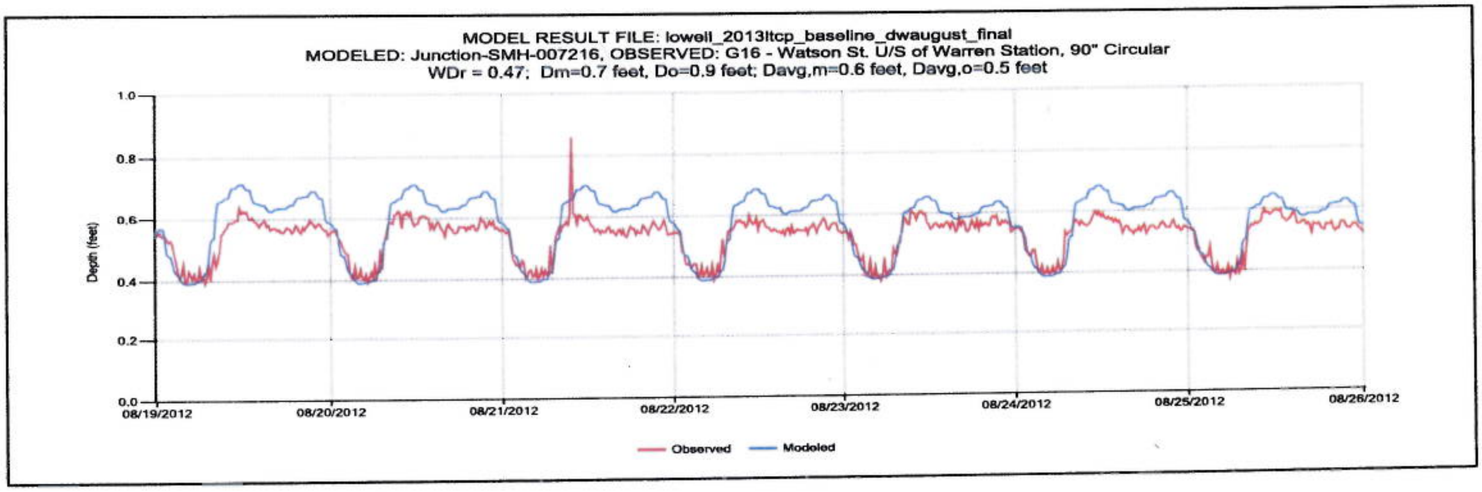


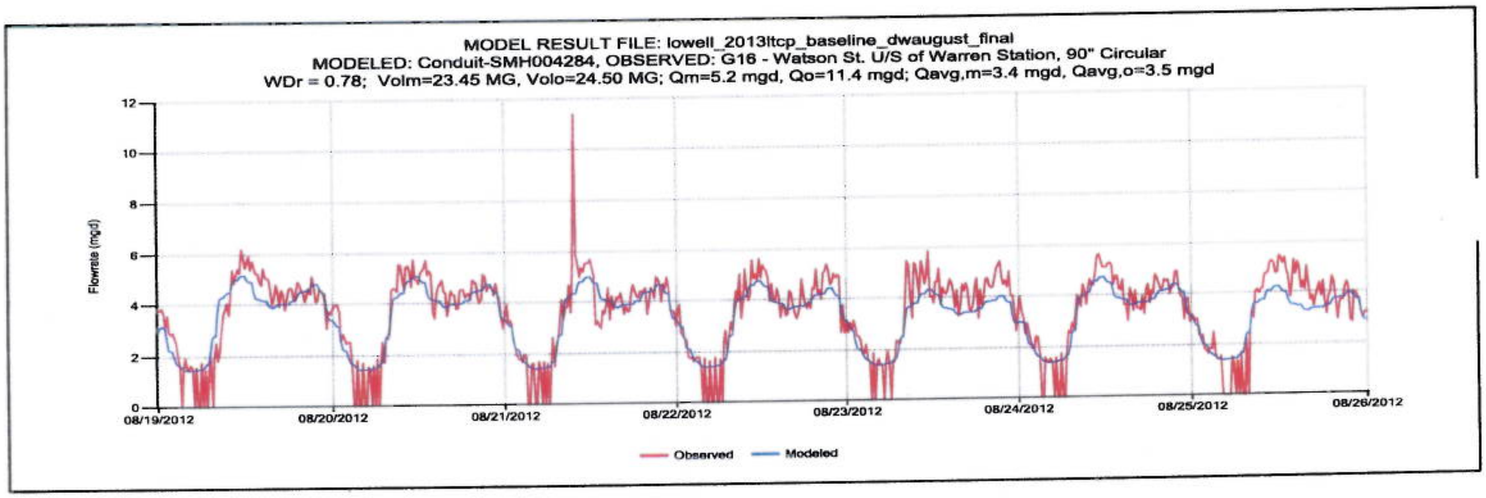


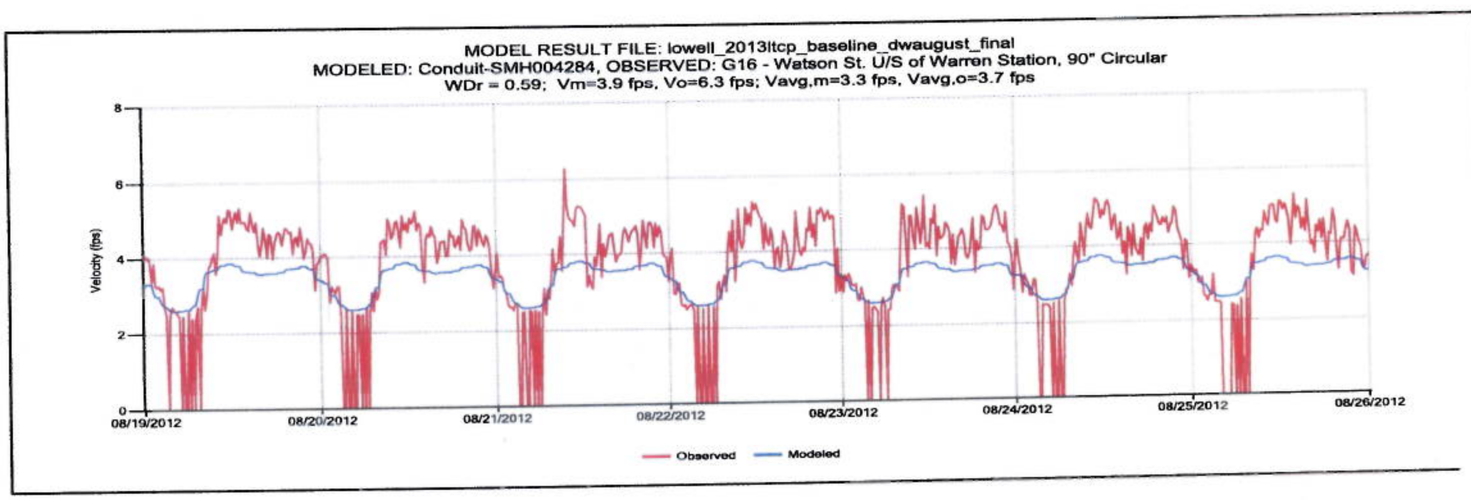

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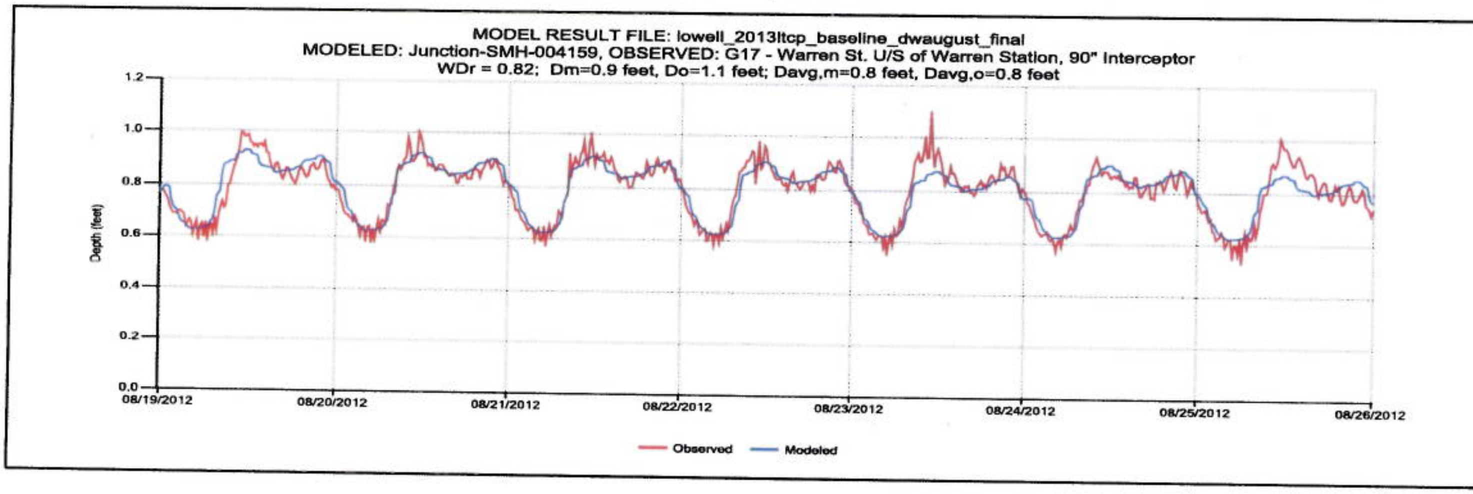
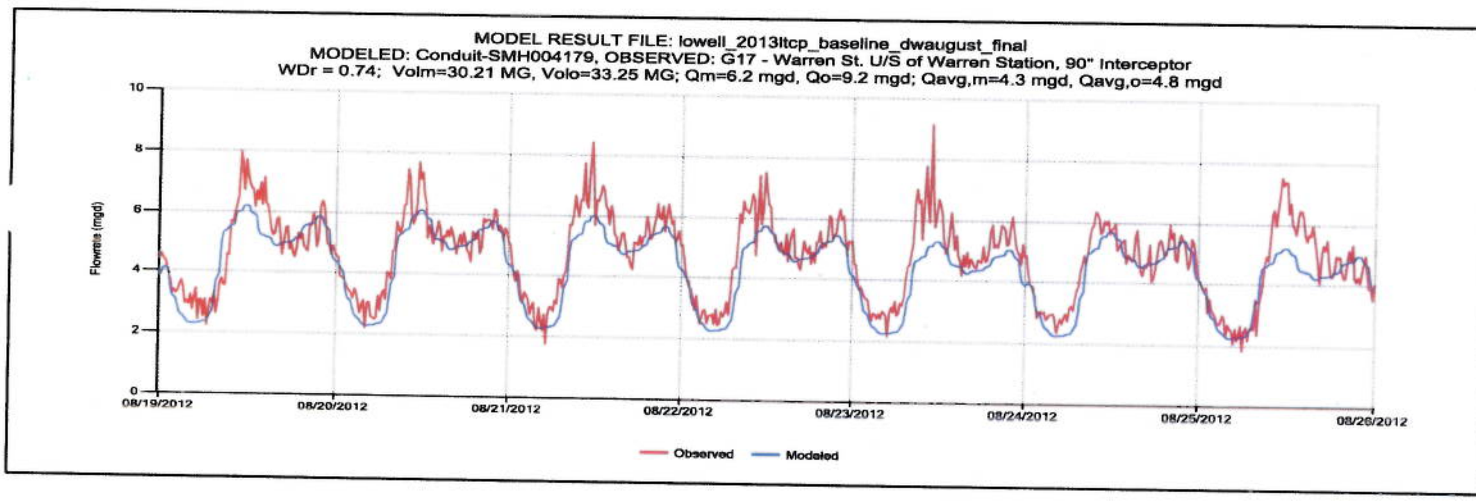
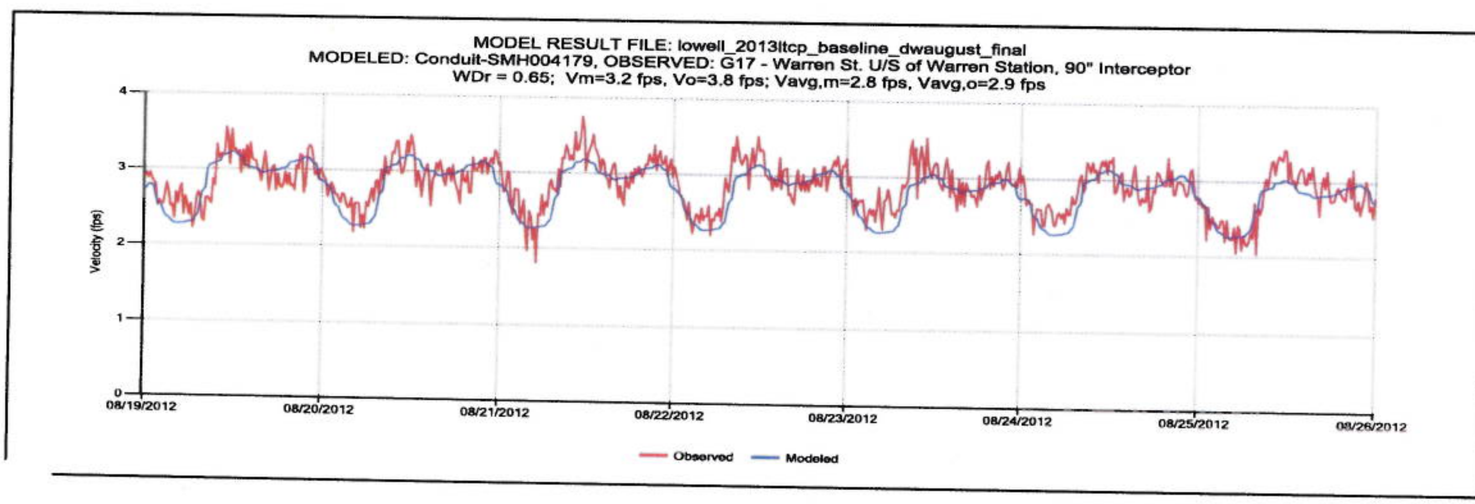
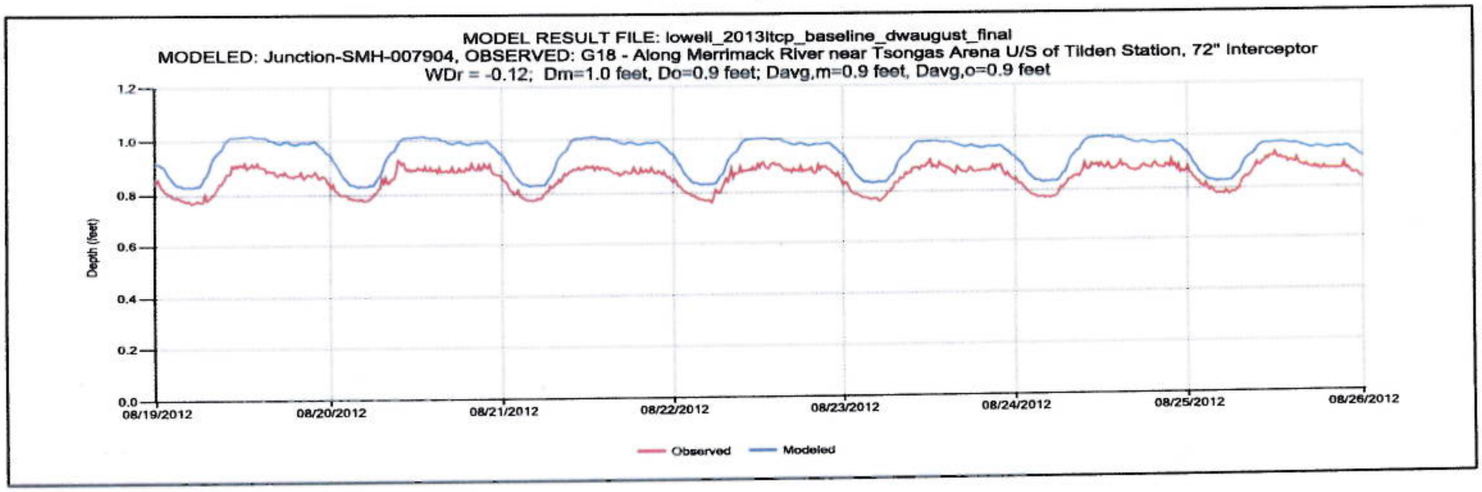
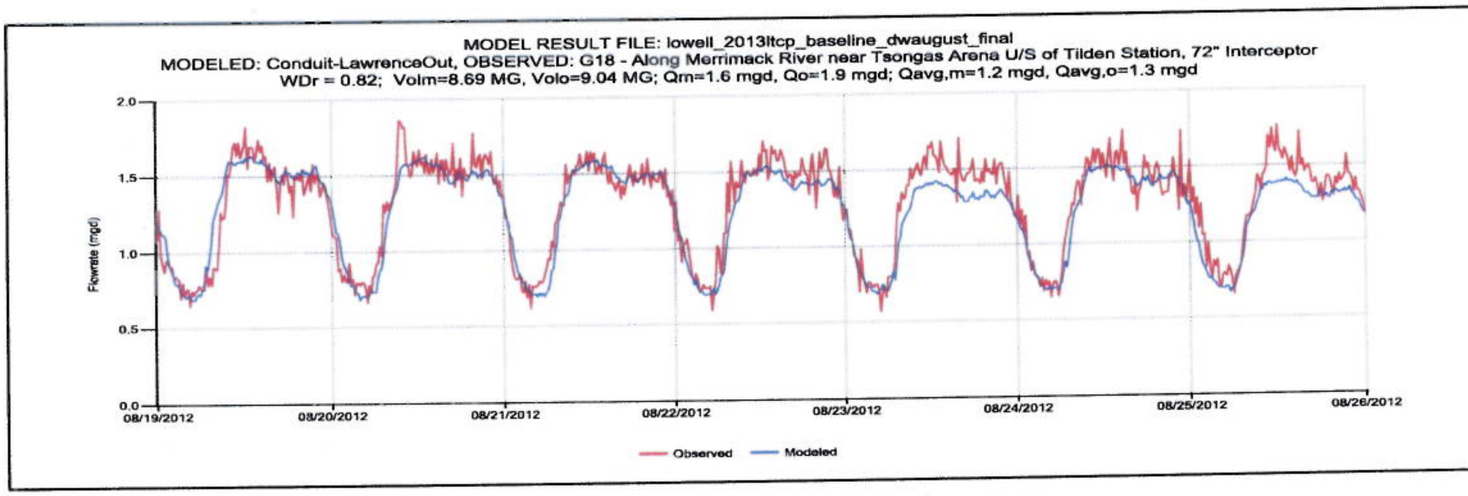


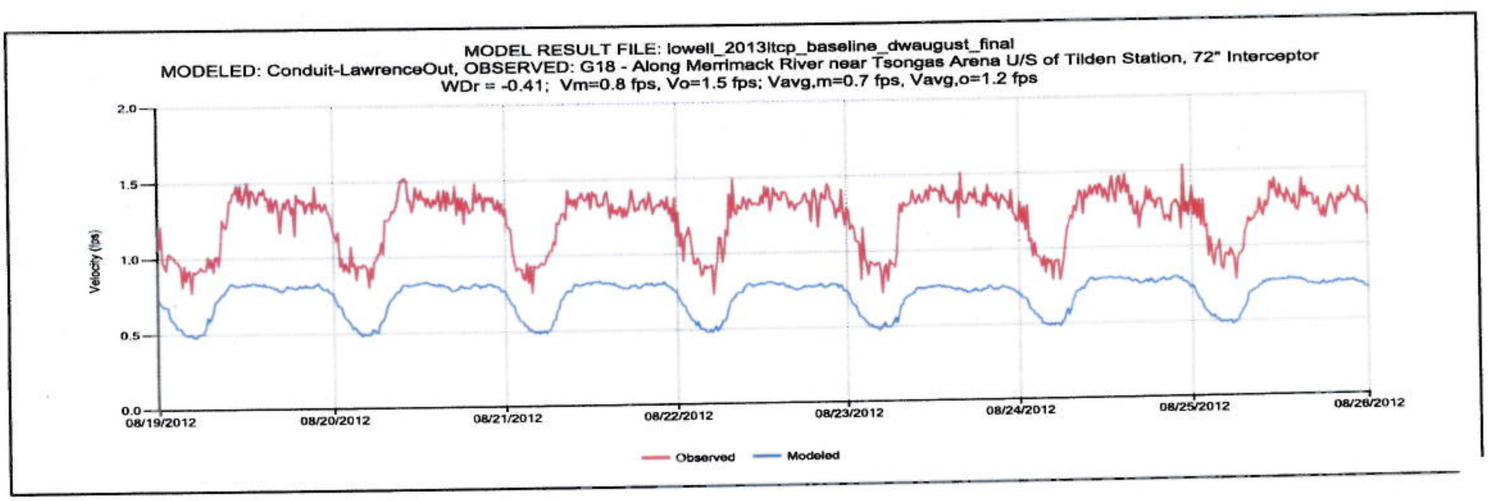



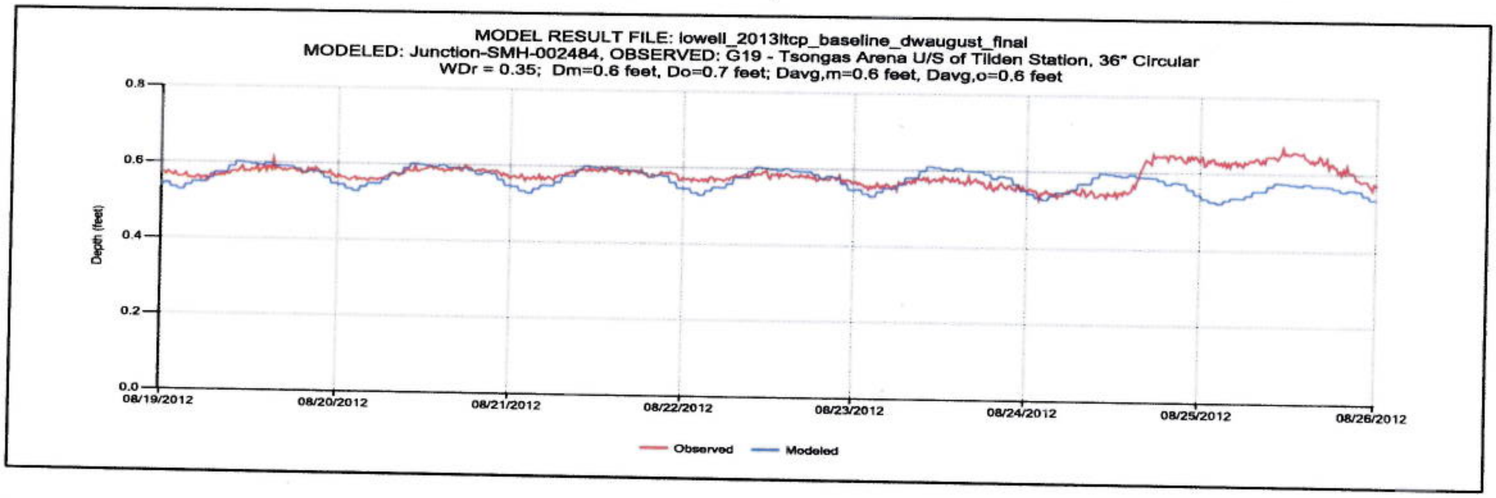
## G18-Fall Dry Period

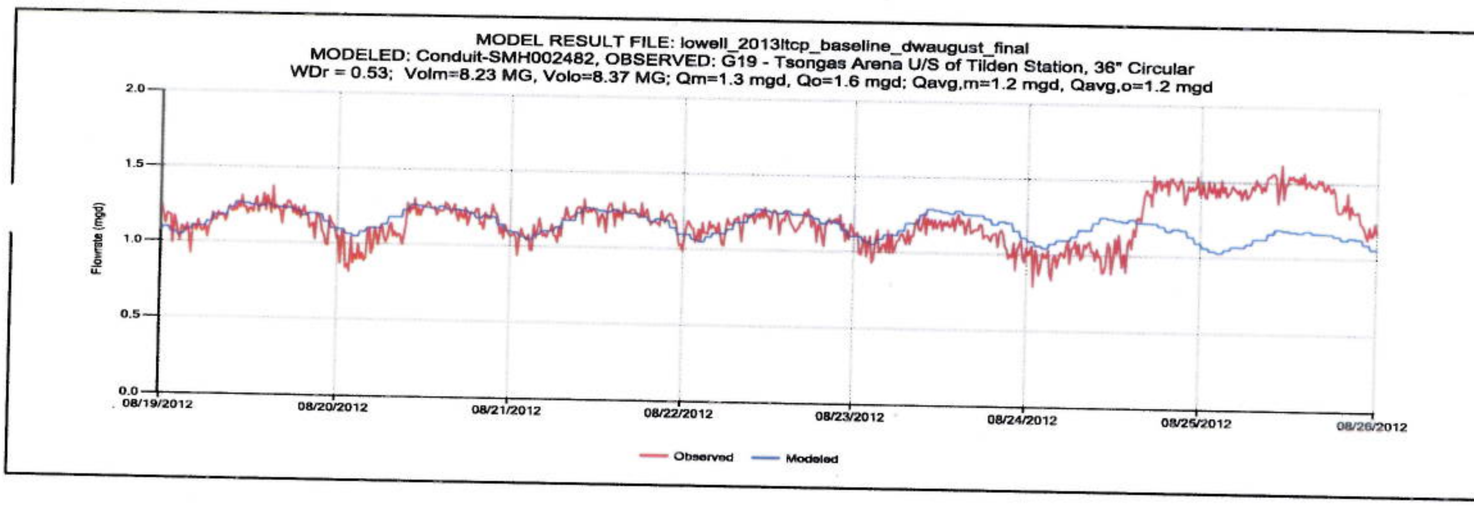


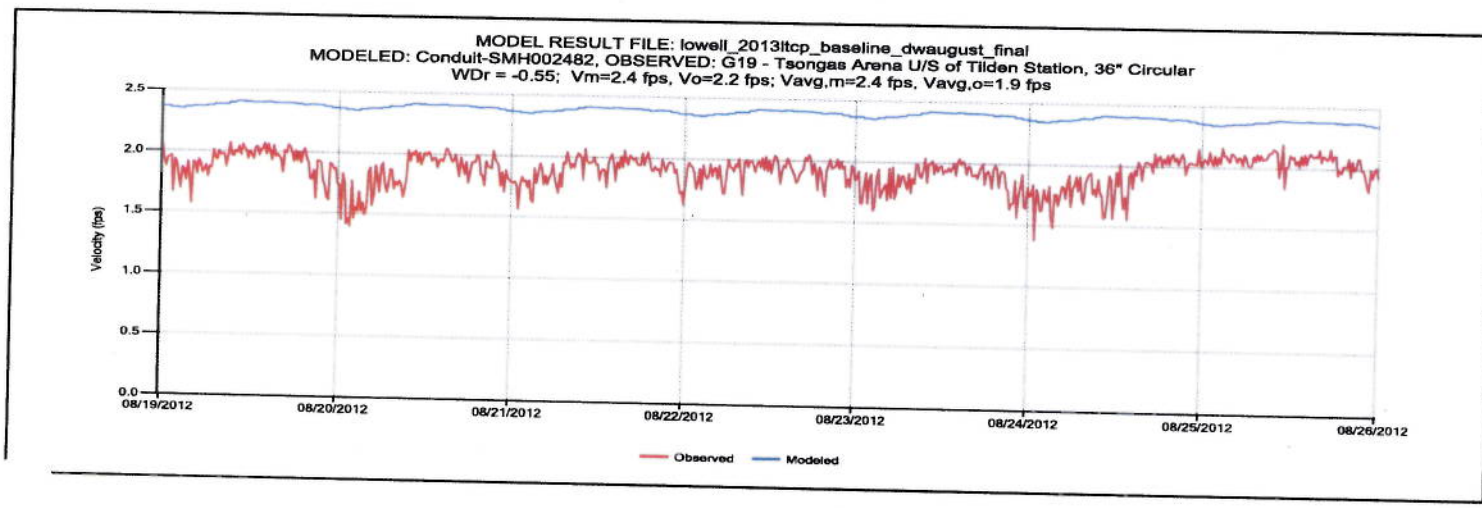



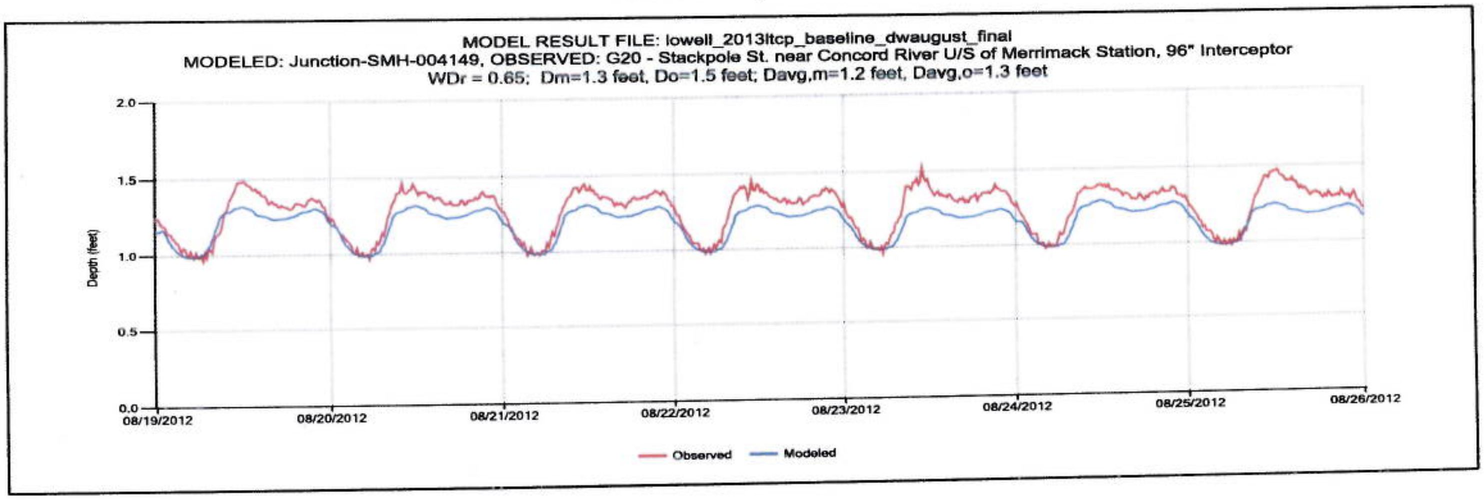
# G19-Fall Dry Period

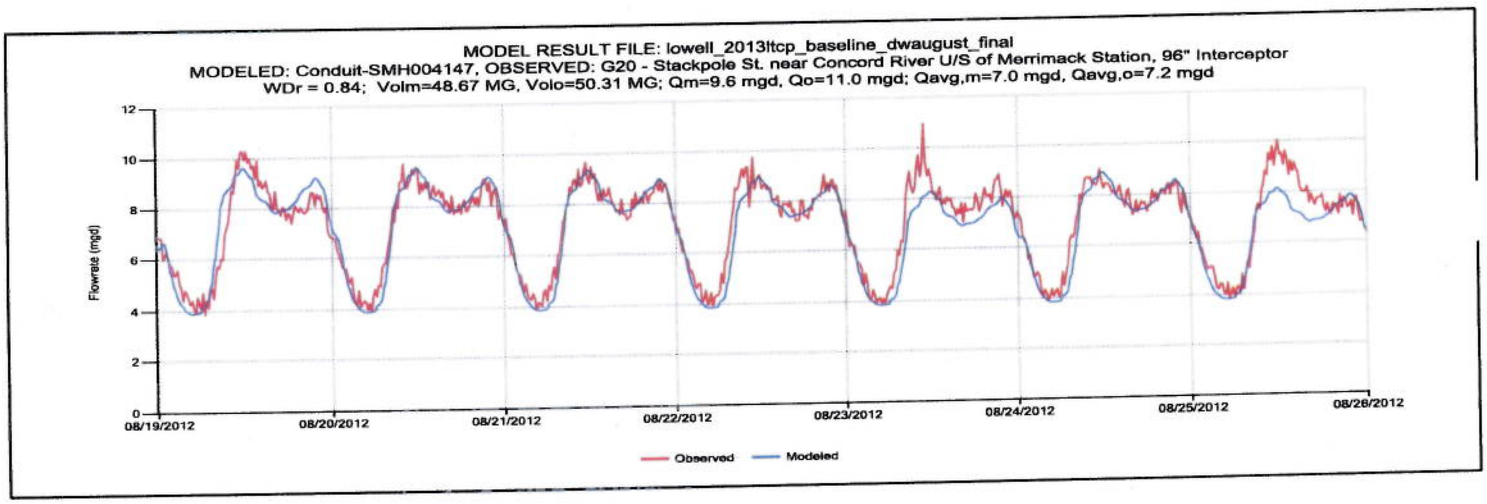


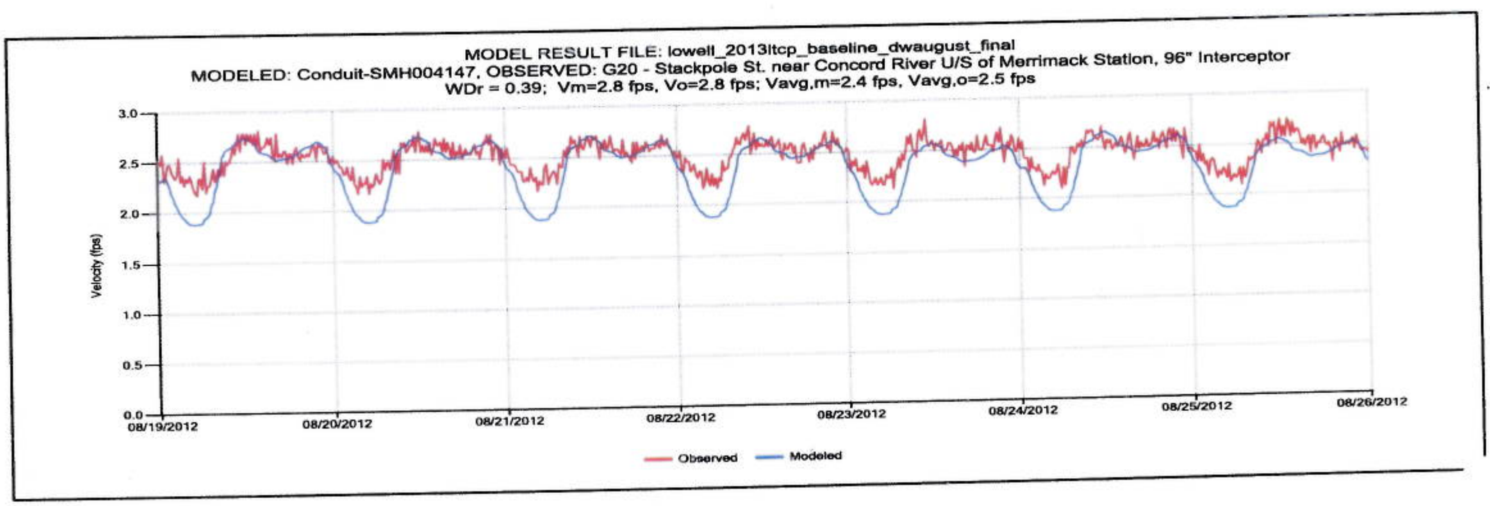



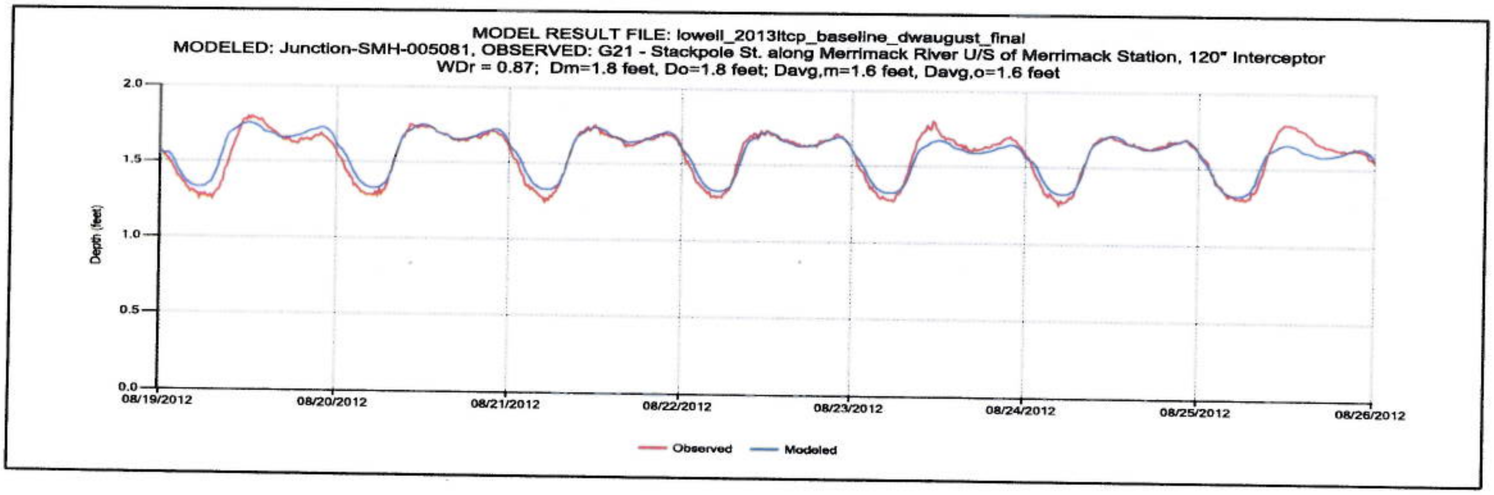
## G20-Fall Dry Period

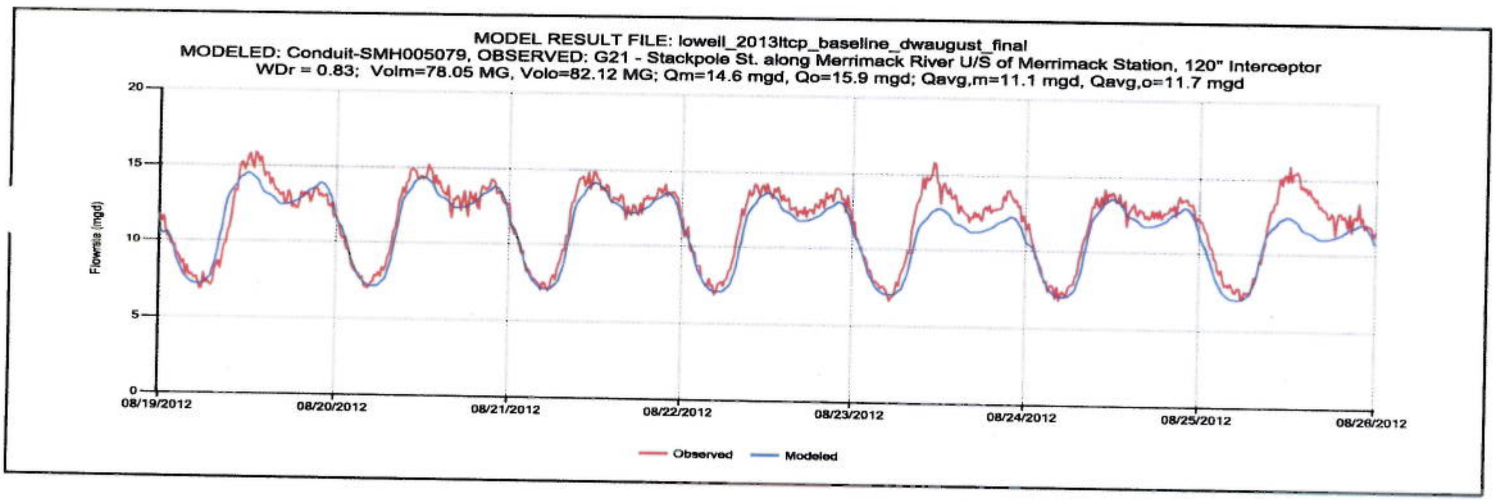


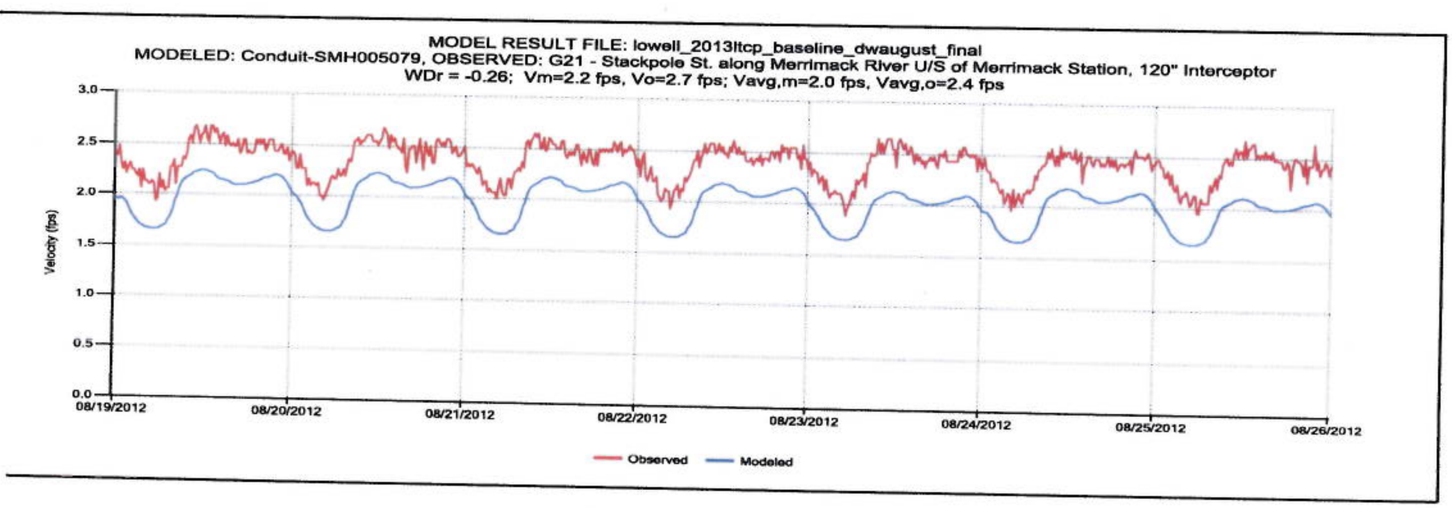



## G21-Fall Dry Period



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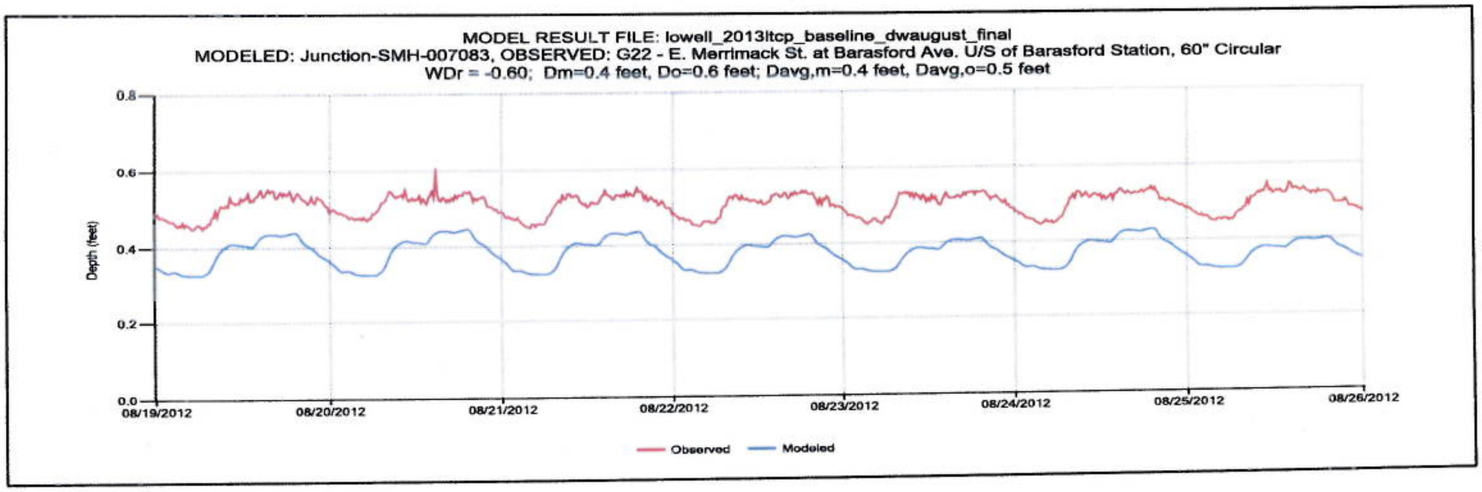
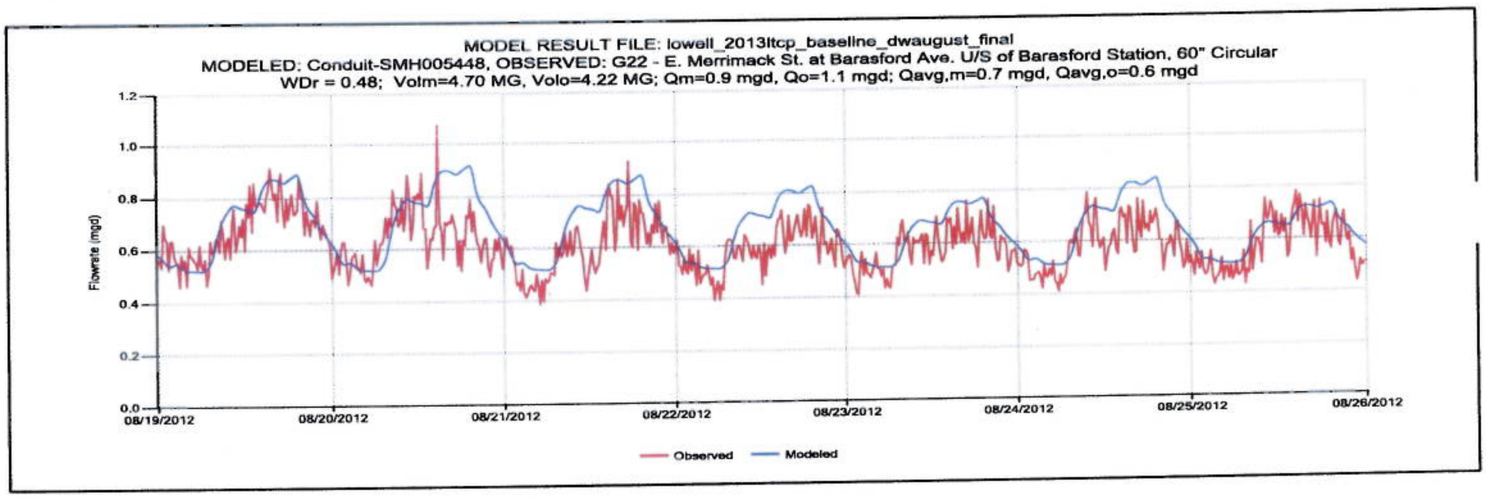
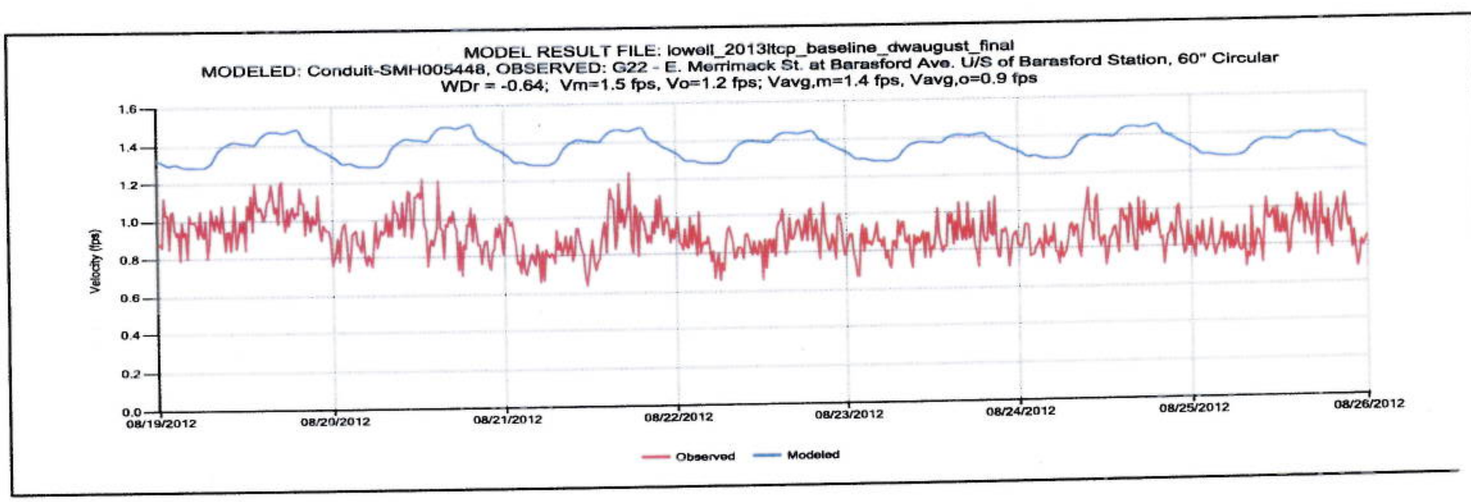
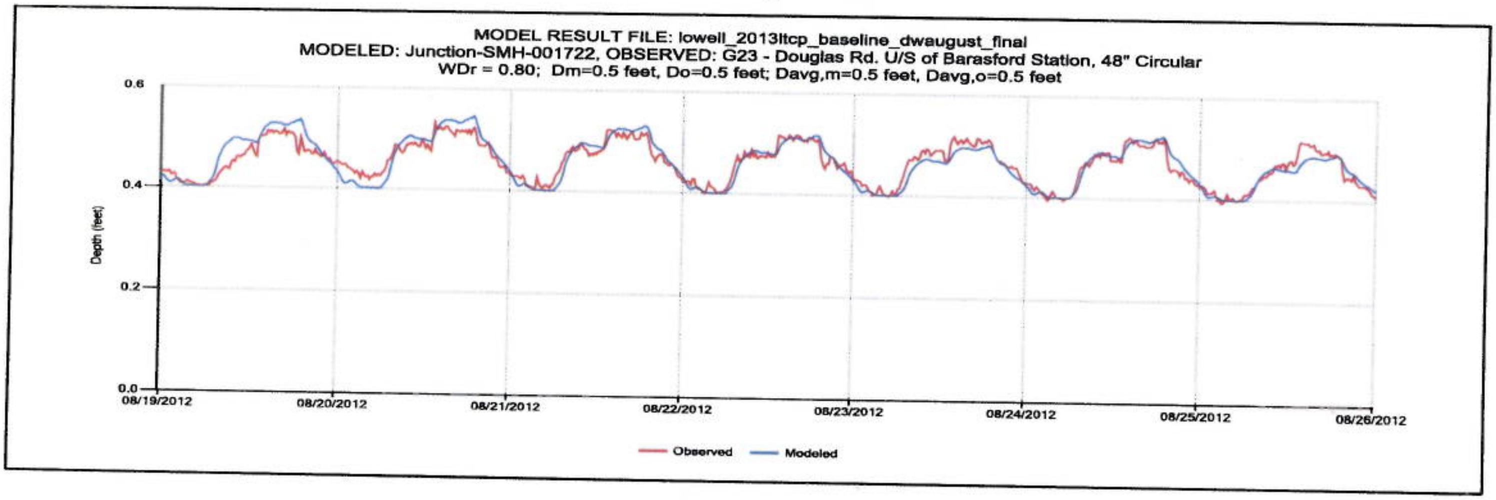
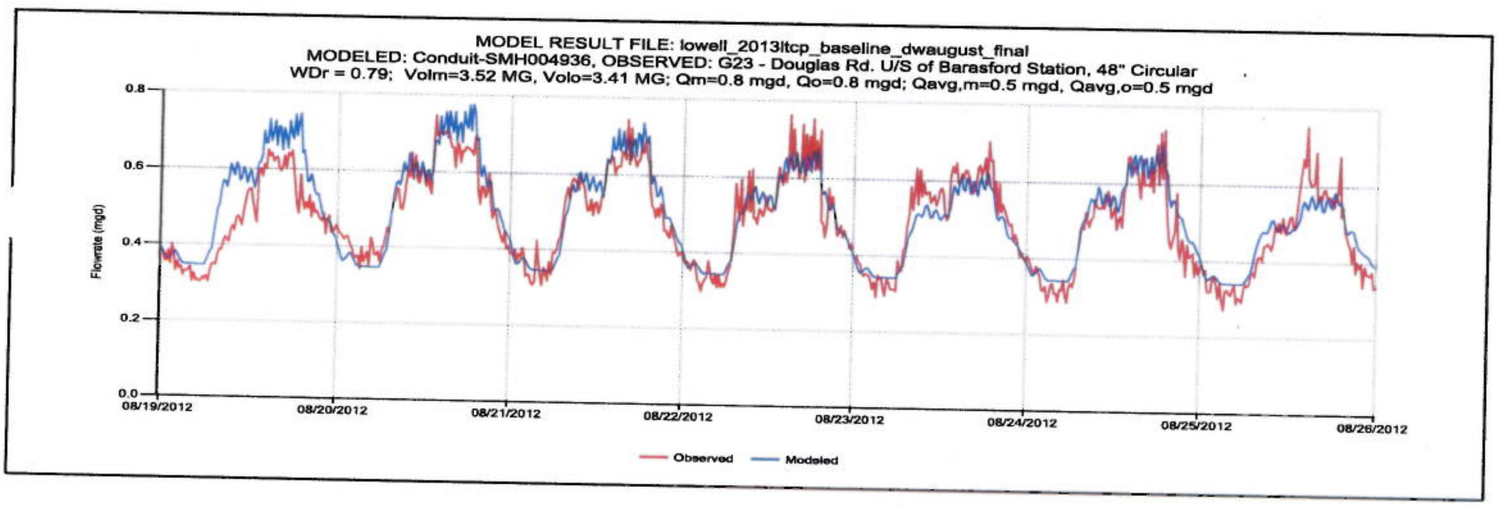


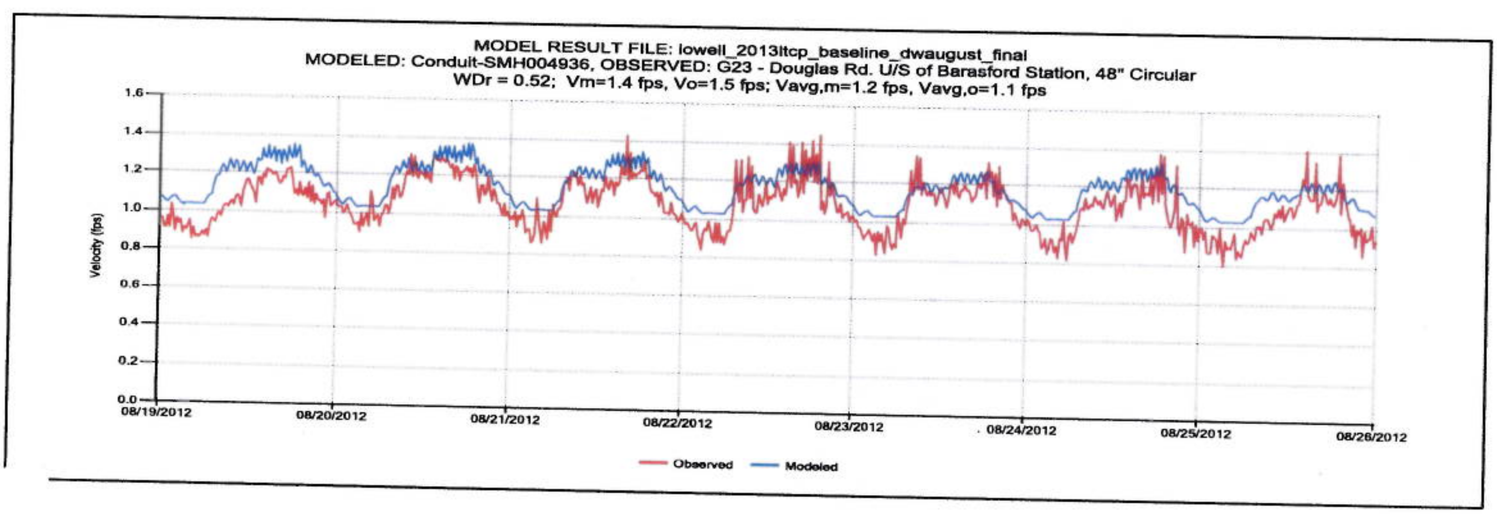



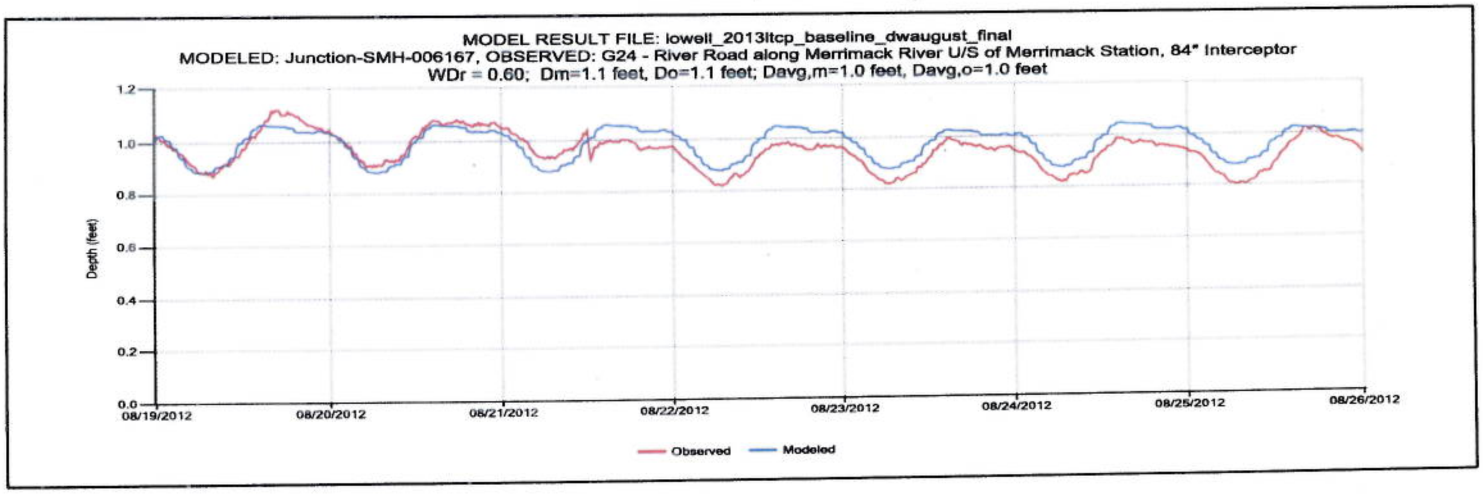
# G23-Fall Dry Period

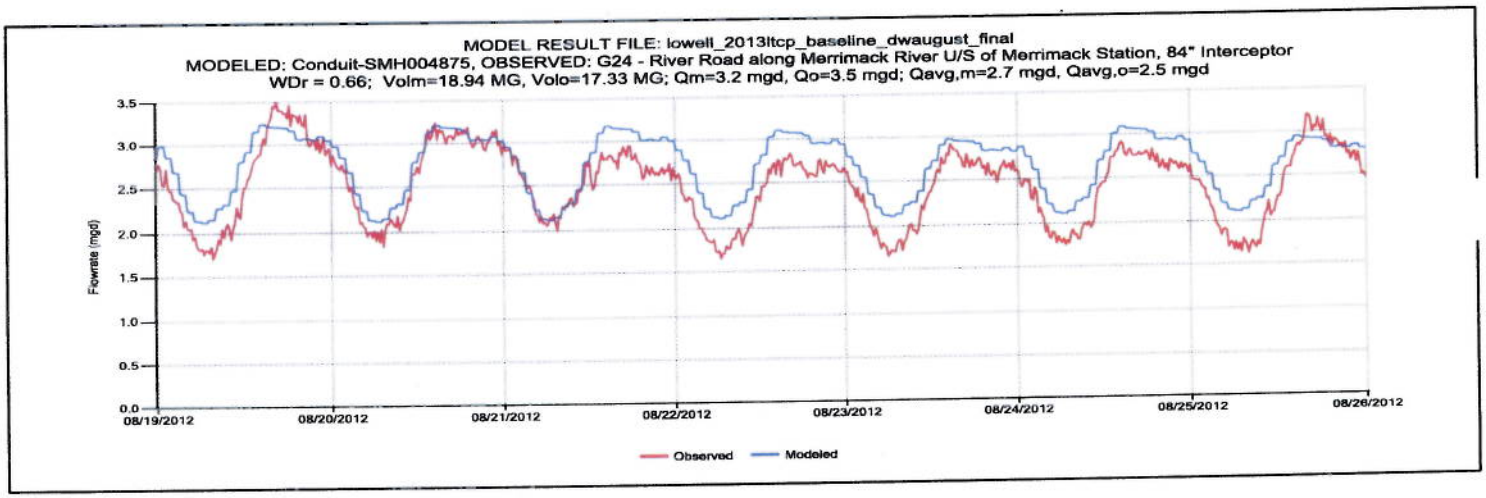


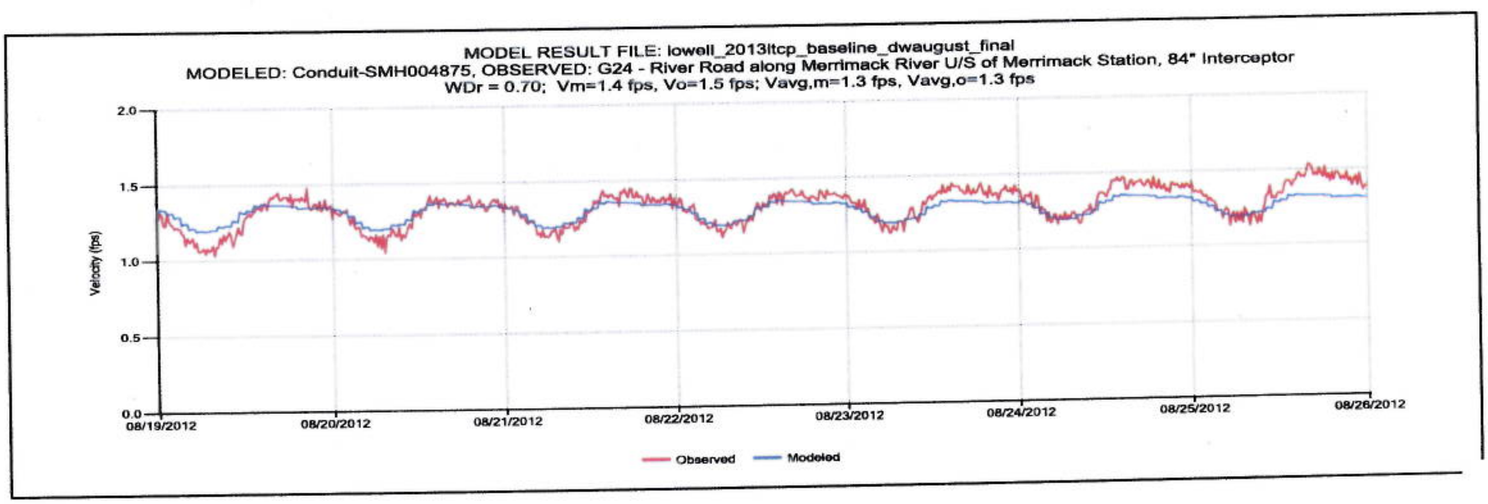



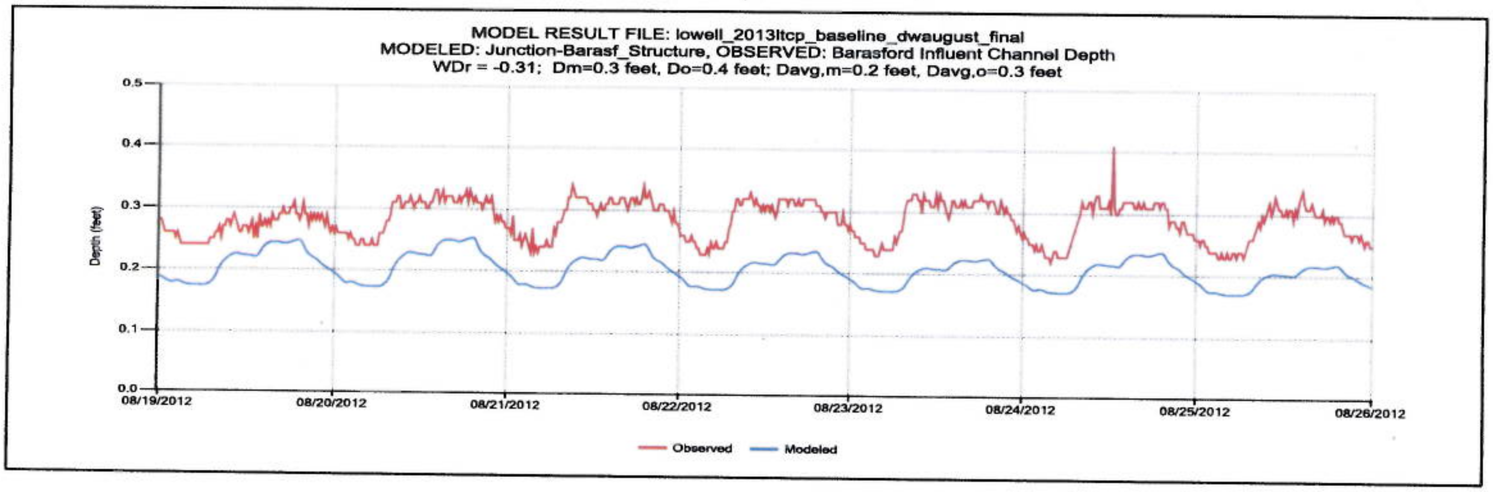
## G24-Fall Dry Period



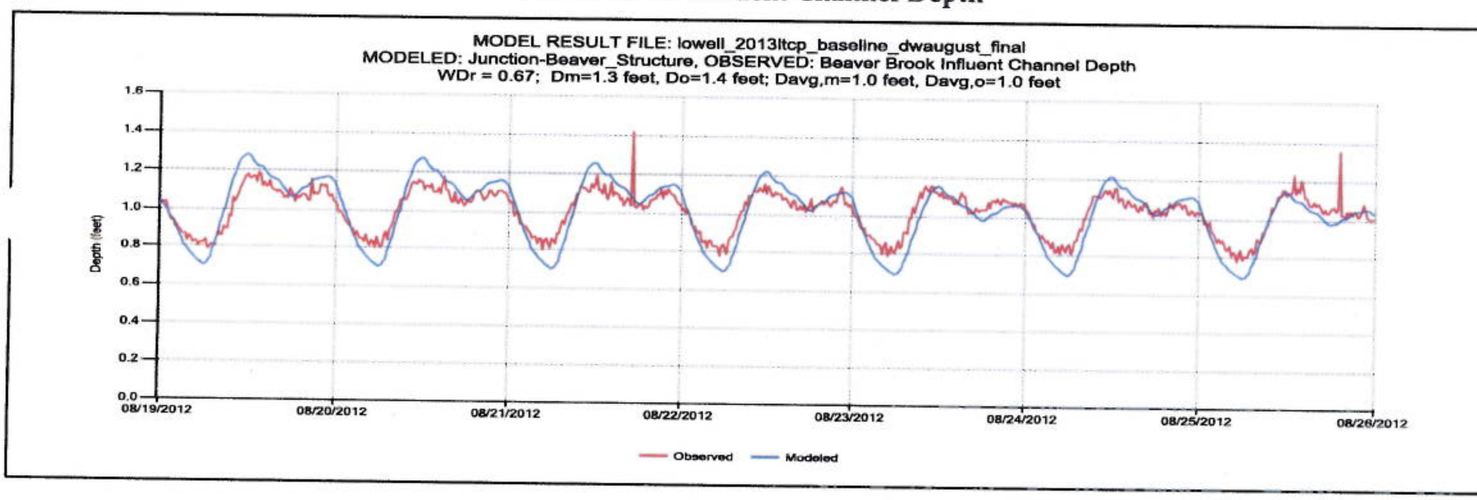



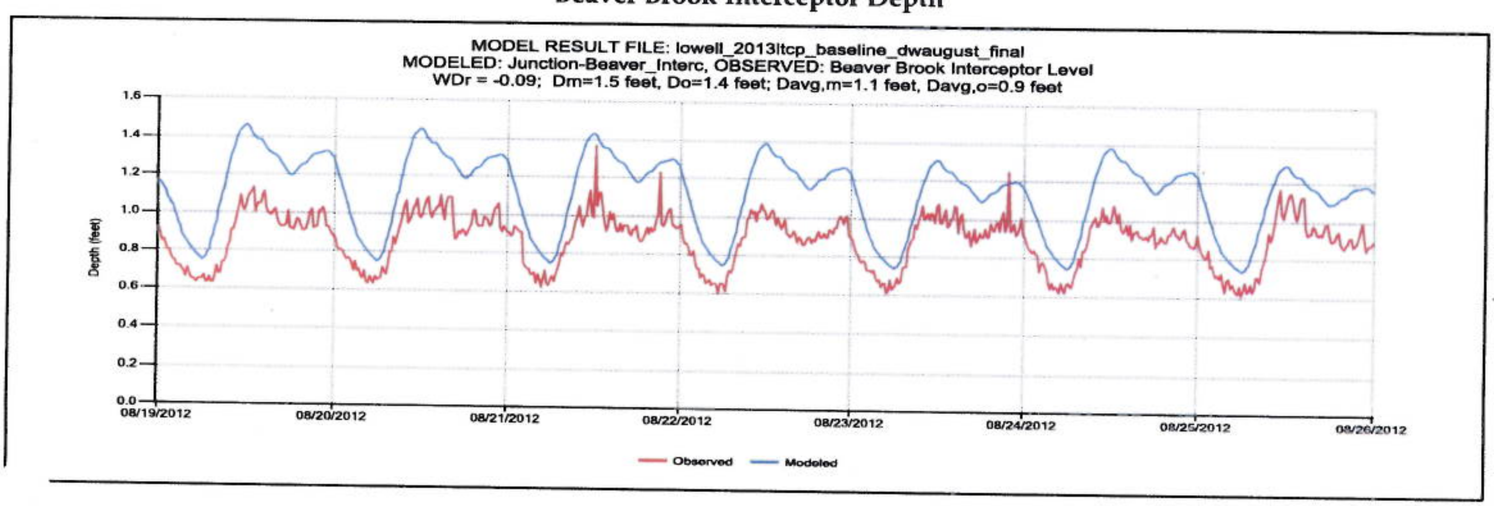
## Barasford Influent Channel Depth



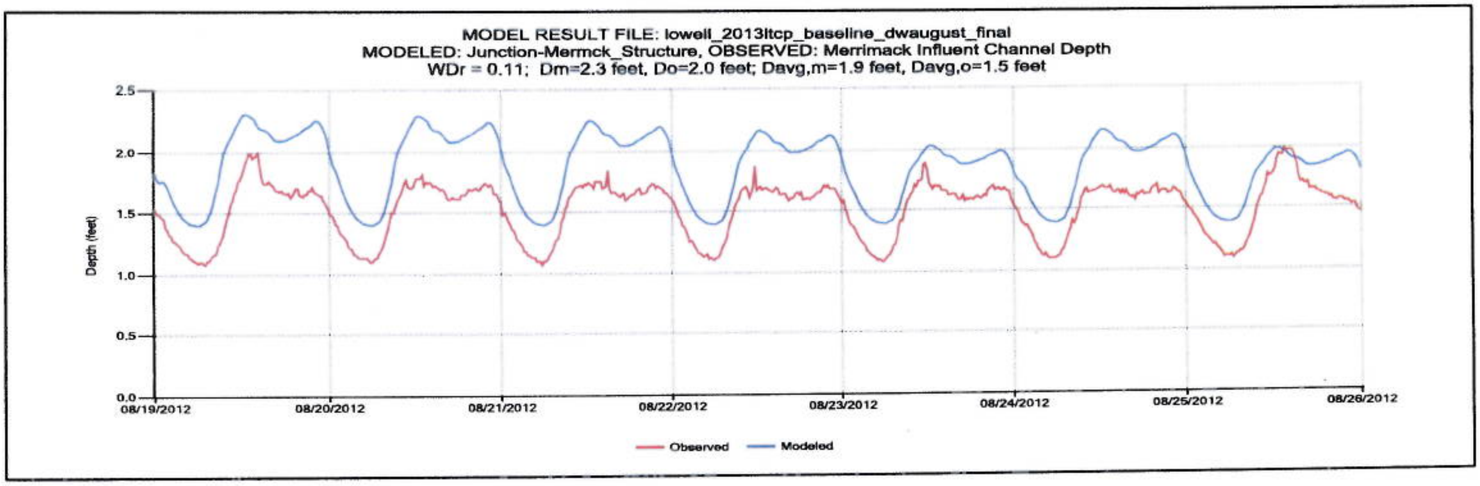

## Beaver Brook Influent Channel Depth



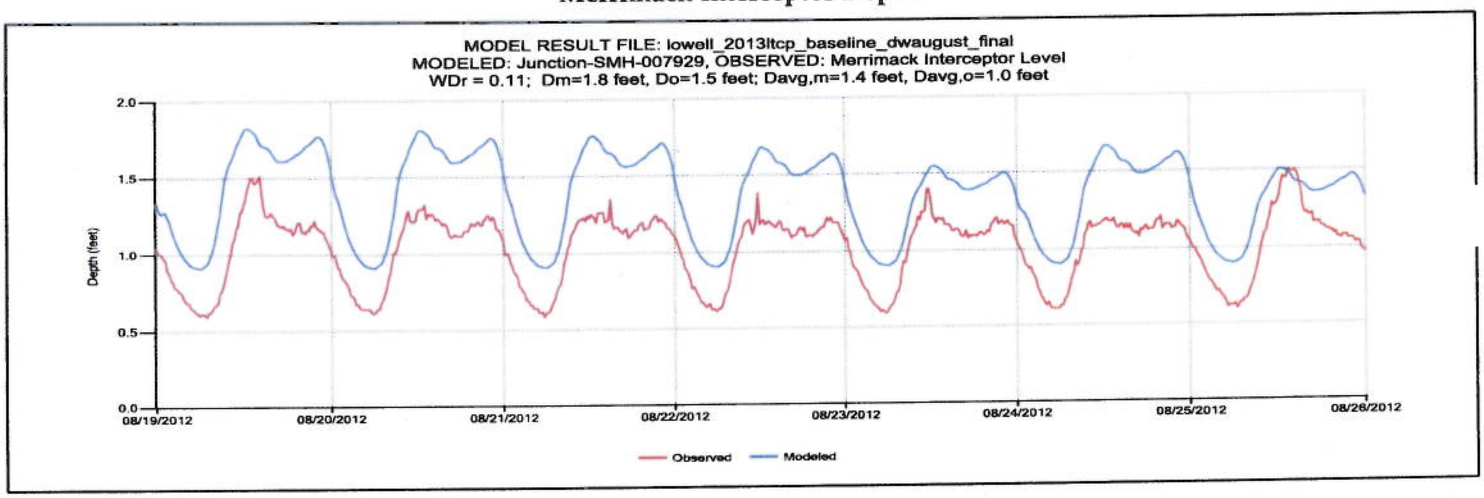

## Beaver Brook Interceptor Depth



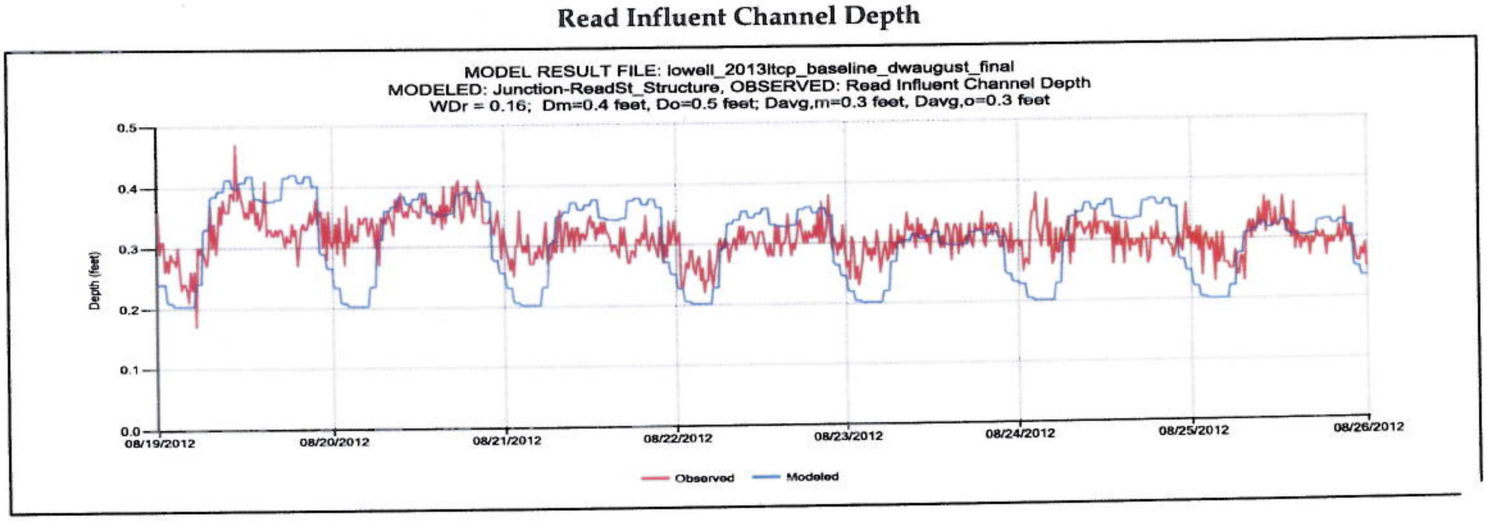
## Merrimack Influent Channel Depth



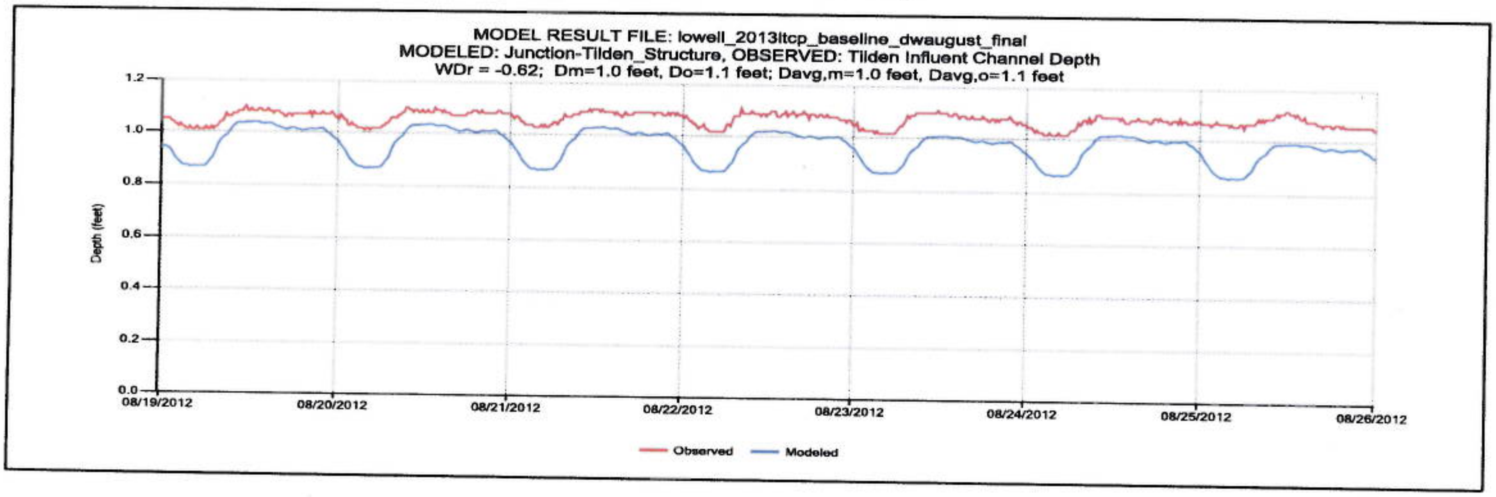

## Merrimack Interceptor Depth



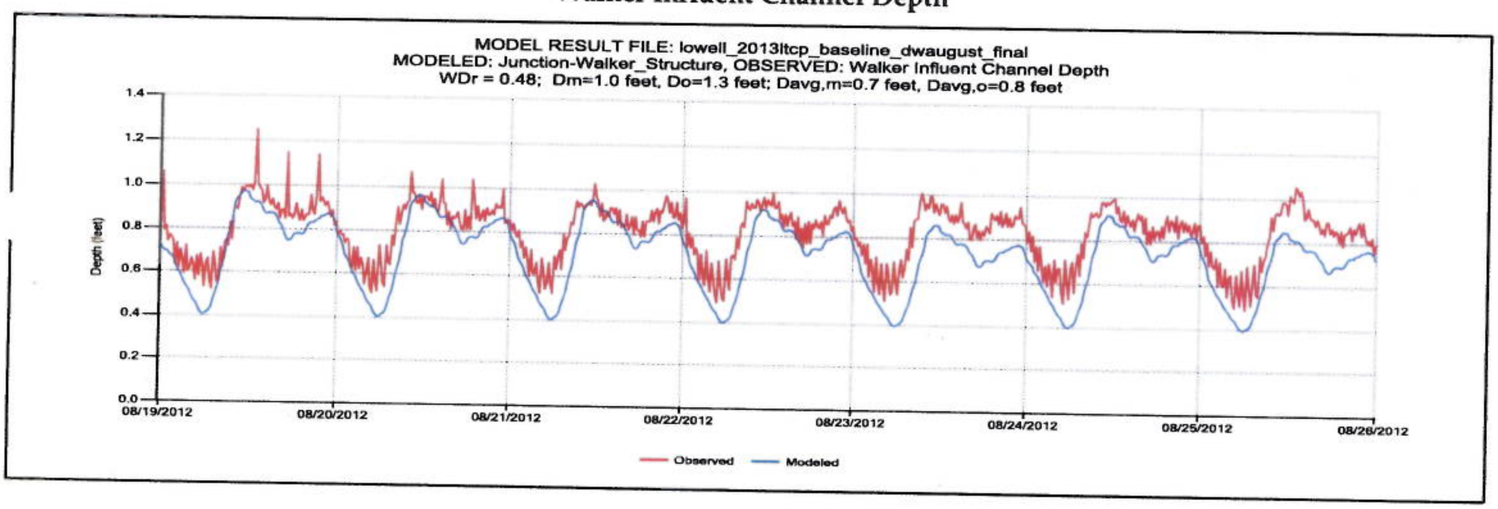

## Read Influent Channel Depth



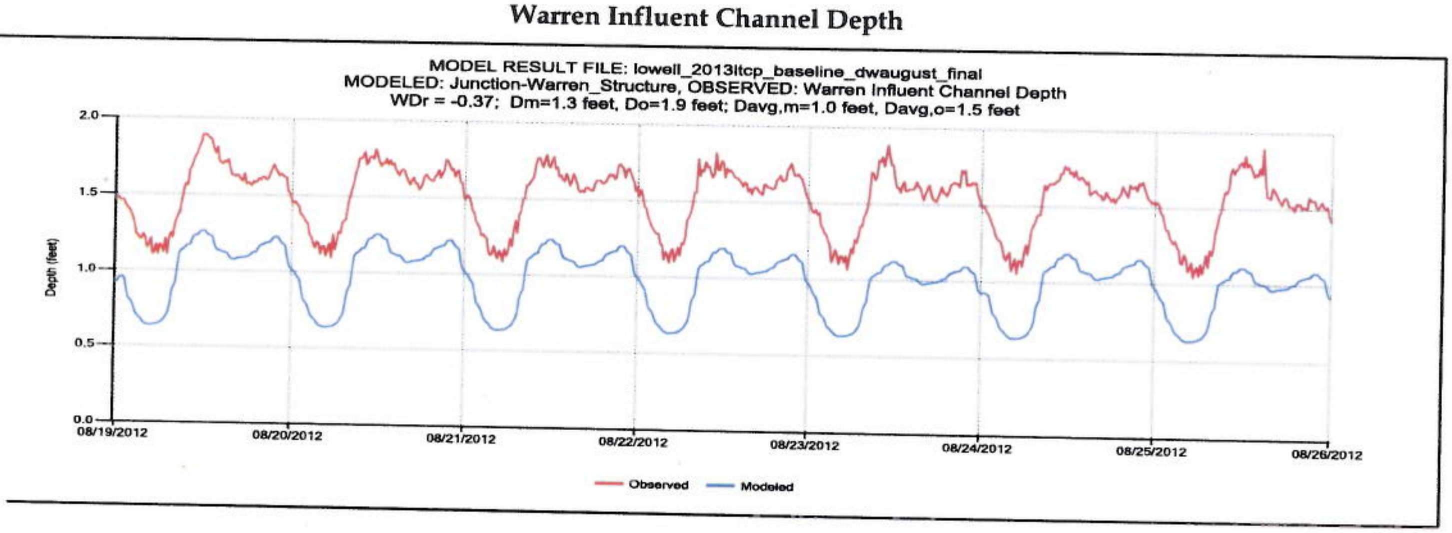
## Tilden Influent Channel Depth



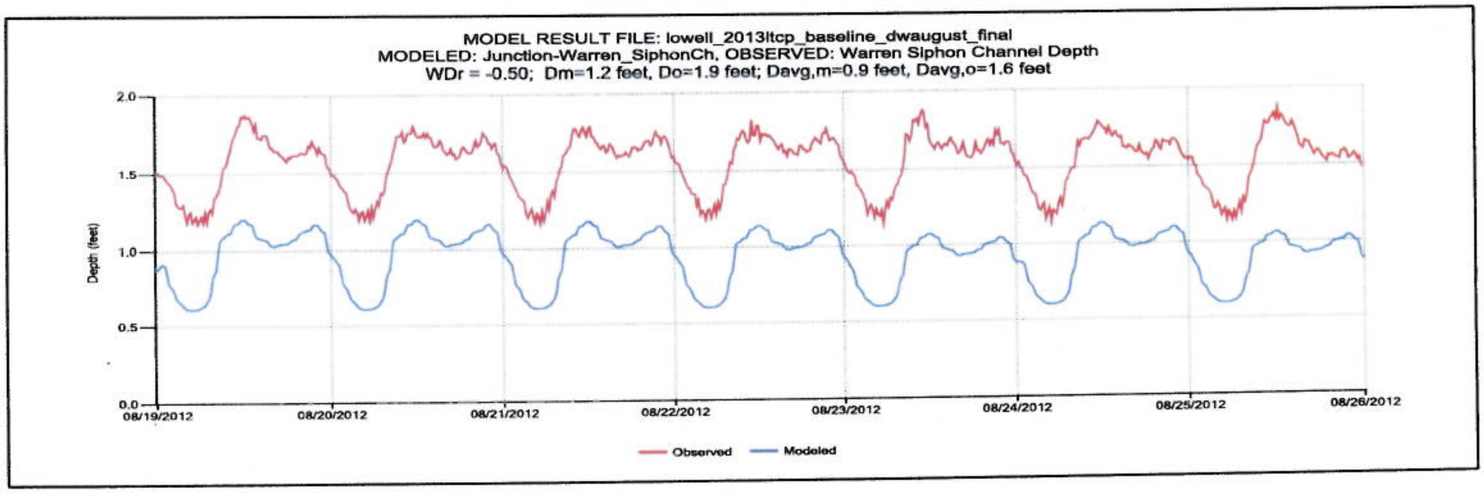

## Walker Influent Channel Depth



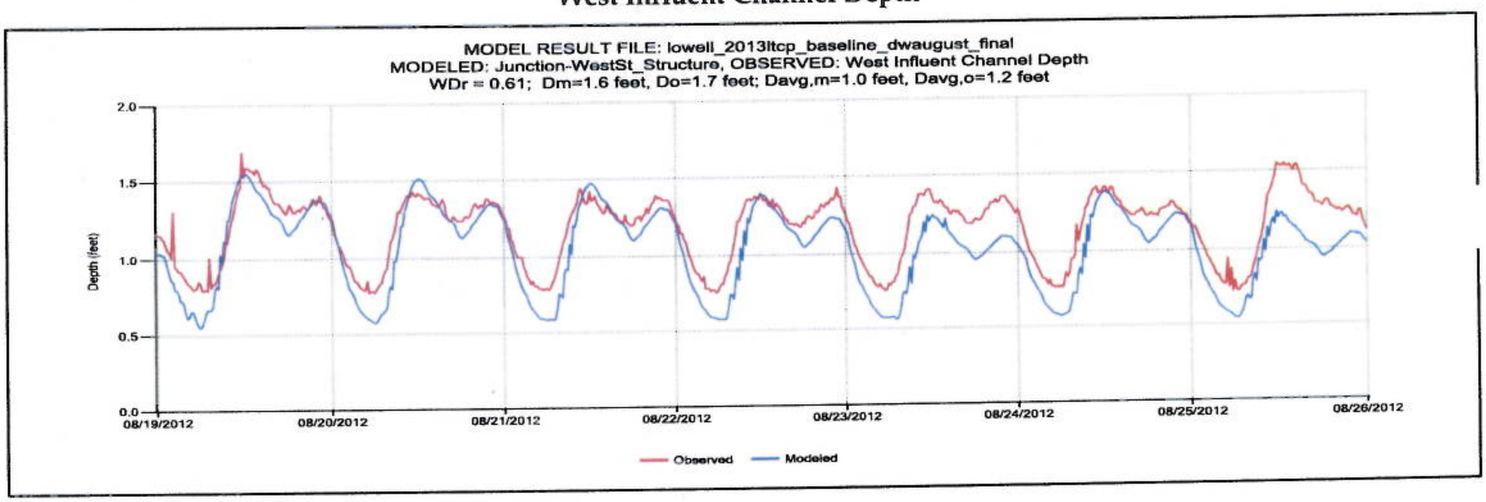

## Warren Influent Channel Depth



## Warren Siphon Channel Depth




## West Influent Channel Depth




## Lowell Regional WWTF Effluent Flow